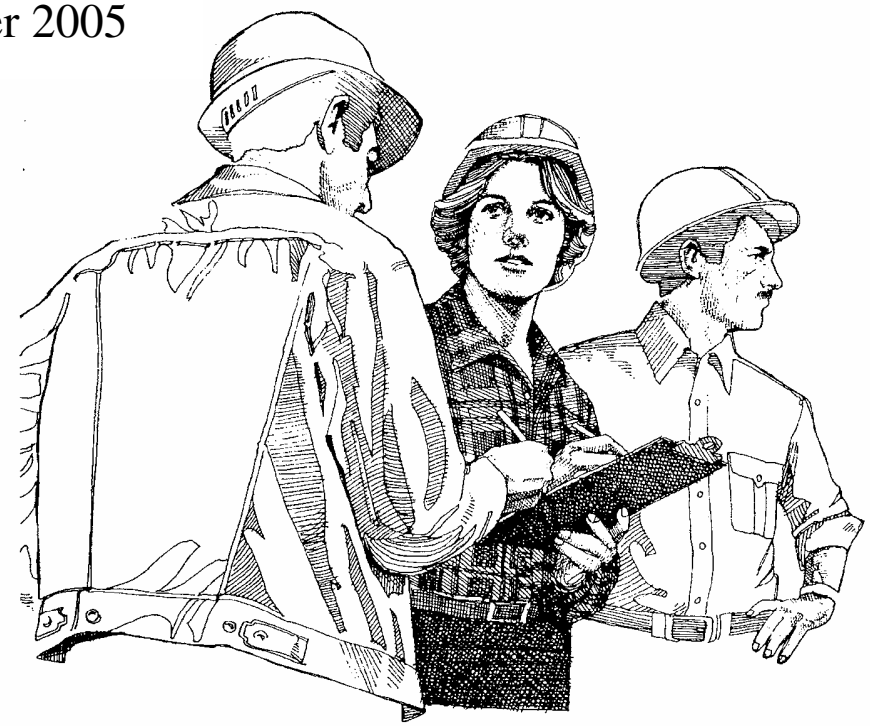
Illumination, Signals and Electrical

Construction Inspector's Training Manual

September 2005



Washington State
Department of Transportation

Illumination, Signals and Electrical

Construction Inspector's Training Manual

Contents

ILLUMINATION, TRAFFIC SIGNAL SYSTEMS, AND ELECTRICAL

Disclaimer; this book is a work book meant for instructional use in conjunction with an instructor lead class. It contains a compilation of material gathered from the available WSDOT manuals and in no way is meant to take the place of those manuals. The manuals are updated regularly and may change the meaning of this work book at any time. For inspection purposes, please use the contract documents provided with your projects, as listed in the special provisions and/or the Standard Specifications.

Terms

"NEC" means National Electrical Code. Copies of the NEC are available from the National Fire Protection Association.

"NEMA" means National Electrical Manufacturer's Association. Copies of NEMA standards are available from the National Electrical Manufacturer's Association.

"NESC" means National Electrical Safety Code. Copies of the NESC are available from the Institute of Electrical and Electronics Engineers, Inc.

"NETA" means International Electrical Testing Association, Inc. Copies of the NETA standards and information are available from the International Electrical Testing Association, Inc.

"NFPA" means the National Fire Protection Association. Copies of NFPA documents are available from the National Fire Protection Association.

"NRTL" means Nationally Recognized Testing Laboratory accredited by the federal Occupational Safety and Health Administration (OSHA) after meeting the requirements of 29 CFR 1910.7.

"RCW" means the Revised Code of Washington. Copies of electrical RCW's are available from the department and the office of the code reviser.

"UL" means Underwriters Laboratory.

"WAC" means the Washington Administrative Code.

Regulations and Code

All electrical equipment shall conform to the standards of the National Electrical Manufacturers Association (NEMA), Electric Utility Service Equipment Requirements Committee (EUSERC), California Department of Transportation document entitled. Traffic signal control equipment shall conform to the contract and these Standard Specifications. EIA Electronic Industries Association, IEEE Institute of Electrical, and Electronic Engineers the Radio Manufacturers Association, the American Society for Testing and Materials (ASTM), the American Association of State Highway and Transportation Officials (AASHTO), the American National Standards Institute (ANSI), whichever is applicable, and to other codes listed herein. In addition to the requirements of these Specifications, the Plans, and the Special Provisions, all material and work shall conform to the requirements of the National Electrical Code, hereinafter referred to as the Code, and any WAC's and local ordinances, which may apply.

Wherever reference is made to the Code, the rules, or the standards mentioned above, the reference shall be construed to mean the code, rule, or standard that is in effect at the date of advertising of the project.

www.lni.wa.gov/TradesLicensing/Rules/files/electrical/wac29646Bjuly2005.pdf
www.fortress.wa.gov/lni/bbip/ for information on contractors!

Industry Codes and Standards

The department of Labor and Industries will recognize the state department of transportation as the inspection authority for telecommunications systems installation within the rights of way of state highways provided the department of transportation maintains and enforces an equal, higher or better standard of construction and of materials, devices, appliances and equipment than is required for telecommunications systems installations by chapter 19.28 RCW and this chapter.

Materials

Equipment List and Drawings

The Contractor is required to submit shop drawings for all types of signal standards and for light standards without pre-approved plans. ***Pre-approved plans are listed in the Contract Provisions and on the web.*** If light standards with pre-approved plans are proposed, no shop drawing submittal is required. There are two different approval procedures for shop drawings. They are the State Bridge and Structures office approval, and Project Engineer approval only. In either case, the Contractor is required to submit six sets of drawings. The two approval procedures include the following:

A. **Bridge and Structures Office Approval**
• Light standards without pre-approved plans.
• Types II, III, IV, V signal standards without pre-approved plans.
• Type SD (Special Design) signal standards.

B. **Project Engineer Approval Only**
• Types PPB, PS, I, RM and FB signal standards, *Standard Plan* J-7a.
• Types II, III, IV, V signal standards with pre-approved plans.

After the Contractor has submitted shop drawings, the Engineer shall make a **field check** of both contract plans and shop drawings. The Project Engineer is responsible for checking the geometric features of these items.
Specific items that should be checked include the following:
• Foundation locations.
• Light source to base dimension (H1), if required in the special provisions and clearance to overhead utility wires.
• Mast arm lengths. If foundation offsets are changed, mast arm lengths must be adjusted.
• Horizontal dimensions from single standard pole centerline to signal head attachment points.
• Vertical dimensions from signal standard base plate to signal mast arm connection points. Assistance is available from the Traffic Design office in estimating mast arm deflection to ensure vertical clearance requirements are met.
• Orientations of mast arms and all pole-mounted appurtenances.
• Signal head mounting details.

• Hand hole location and orientation.
• Base treatment for lighting standards (fixed, or slip, or breakaway).

If there are **no changes** to dimensions or orientations, the Project Engineer shall mark the drawings with a statement that all standards shall be fabricated according to dimensions and orientations shown in the Contract.

If there are **corrections**, the Project Engineer shall note all corrections on one set of shop drawings, with **green** markings only, and attach copies of signal standard charts and/or luminaire schedules from the contract, noting any dimension changes in green. Transmittal Letter, Form 410-025, shall be used to submit the entire package.

The State Bridge and Structures office will conduct a structural review, and mark all sets in **red**, incorporating the Project Engineer's geometric review comments.

The six sets of shop drawings for supports without pre-approval shall be submitted to the State Bridge and Structures office, which will coordinate approval with the State Materials Laboratory. After approval, the State Bridge and Structures office will retain one set and forward two sets to the State Materials Engineer and send three sets to the Project Engineer. One of the State Materials Engineer's sets will be forwarded to the Fabrication Inspector. The Project Engineer will send two sets to the Contractor, who will forward one set to the Fabricator. See the Shop Plans and Working Drawings Table in Chapter 1-2.4H of the Construction Manual.

Contractors' Shop Plans and Working Drawings

In general, all shop drawings and supplemental details submitted by the Contractor should be checked, in detail, for conformance to all contract requirements before forwarding on for approval or further actions by others. A Change Order is required for any deviation from the contract plans. Any conflicts with the contract plans that have been detected or revisions that may be desired by the Project Engineer should be noted on one copy of the drawings being forwarded to Headquarters for approval. If Change Orders to cover any deviations from the contract plans have been issued, or are being processed, those changes should also be noted. Use Form 410-025 to transmit all listed bridge and structure plans to the Bridge and Structures Engineer.

Shop Plans for Luminaire and Traffic Signal Poles & Metal Bridge Rail

Reviewer
6 sets to Project Engineer or Bridge & Structures Engineer
Approving Authority
Bridge & Structures for light standards and Types II, III, IV, V and SD (special design) signal standards.
Project Engineer for Types PPB, PS, and I signal standards shown on Standard Plan J-7a.
Distributor
Project Engineer 2 sets to Contractor, 2 sets to Fabrication Inspector

The Project Engineer should maintain a **log** of all shop plans or other drawings received for each contract. Shop plans for items that conform to the contract plans or a standard plan, except those listed above, should be checked and approved by the Project Engineer.

If pre-approved shop plans have been submitted, a **structural review** by the State Bridge and Structures office is not required. The Project Engineer shall mark all changes in red on all six copies. The Project Engineer will then retain one set of plans, forward one set to the Regional Operations/Construction Engineer, two sets to the Fabrication Inspector, and two sets to the Contractor, who will forward one set to the Fabricator.

All drawings shall be clearly marked ("Approved as Noted", "Returned for Correction", or "Approved") before returned to the Contractor, whether reviewed and checked by the Project Engineer or the Bridge and Structures Office.

Construction Requirements

General

Illumination and traffic signal systems, due to the very nature of the work, are a highly specialized type of installation. In designing these systems, every effort is made to avoid problems for construction, maintenance, and the utility company. If problems arise, the Engineer should contact those responsible for the design and operations for help in solving them.

Generally, during the design of an illumination or traffic signal system, the serving utility is consulted concerning the availability of power, the voltage needed, the location of the most convenient point of service, and agreements are prepared prior to the awarding of the contract. The Project Engineer should review all utility agreements and contact the serving utility as soon as the Contractor commences work to arrange for the actual service connections and other work which may have been agreed upon. The matter is important since, in many cases, the utility will have to extend lines, install transformers, and do other related work. Upon completion of the contract, the Project Engineer will instruct the serving utility to direct all future billings to the appropriate maintenance division.

Inspection on electrical projects involves two aspects of work. The first of these is the **physical aspect** wherein conformance to the plan requirements relative to the materials used and general construction techniques must be the criterion for judgment. An Inspector who is thoroughly familiar with the requirements of Section 8-20 of the *Standard Specifications* and with normal construction techniques should be assigned the inspection responsibility for this portion of any signal or illumination project. The Fabrication Inspector shall be consulted if lighting or traffic signal standards arrive on the jobsite without prior inspection.

The second aspect of electrical work involves the **conformance** by the Contractor with the contract requirements in addition to the requirements of the State electrical construction codes and the National Electric Code. This aspect of inspection must be performed by an electrical Inspector. A further consideration within this aspect of work involves any changes authorized in the contract plans as it may affect circuit stability, circuit adequacy, and the ability of related electrical control devices to properly function through any such change of plans. The performance testing of the system is part of the second aspect of the electrical work.

Electrical work is a specialized field of endeavor within WSDOT; therefore the Project Engineer must **arrange for the assistance** of an electrical Inspector from the Regional office. The electrical Inspector shall make periodic inspections throughout the course of construction of all electrical projects and shall advise the Project Engineer of appropriate times to enable the Project Engineer to occasion the required field tests of electrical circuits, as discussed in Section 8-20 of the *Standard Specifications,* at such times that cause a minimum interference of the work scheduled by the Contractor.

Should any question arise on a project pertaining to the technical nature of the work, the Project Engineer shall consult with the electrical Inspector or with the Regional Traffic Engineer, if necessary.

Our plans and specifications are designed generally to conform with existing national electrical codes. There are instances when the Department permits methods of construction that are considered equivalent to state and national codes.

Generally, local inspection authorities do not inspect highway work that is within the state highway right of way. From time to time, however, the Department of Labor and Industries or local electrical inspectors may visit a project to inspect or review the Contractor's work. They should be treated courteously and their judgment respected. The Department does have authority to permit alternate methods when equivalent objectives can be met if the work is within the State right of way. Should any question arise over a conflict between our plans and their opinions, the matter should be referred to the State Construction Office for advice.

All materials for installation on illumination and traffic signal projects shall be selected off the *Qualified Products List* (QPL)

The QPL is compiled by WSDOT Environmental & Engineering Programs Division, Materials Laboratory and published by WSDOT Engineering Publications. WSDOT in no way endorses any of the products listed in this publication. Where there is a conflict between the QPL and the contract provisions, the contract provisions shall take precedence over the QPL. WSDOT is not responsible for errors or omissions in the QPL

Products that do not perform or are found to be non-compliant with WSDOT Specifications may be removed at any time from the QPL. The product will not be re-entered into the QPL or approved for use in the State of Washington until such time that adherence to the Specifications can be verified and the product has undergone satisfactory performance evaluation

Qualified Product List

Product Information

Manufacturer: 3M Co.-Electrical Division, Low Voltage, Austin-TX

Product Name: Model No. 82A, 82-B1 and 90-B1

Standard Spec : 9-29.12, Electrical - Electrical Splice Materials and Kits

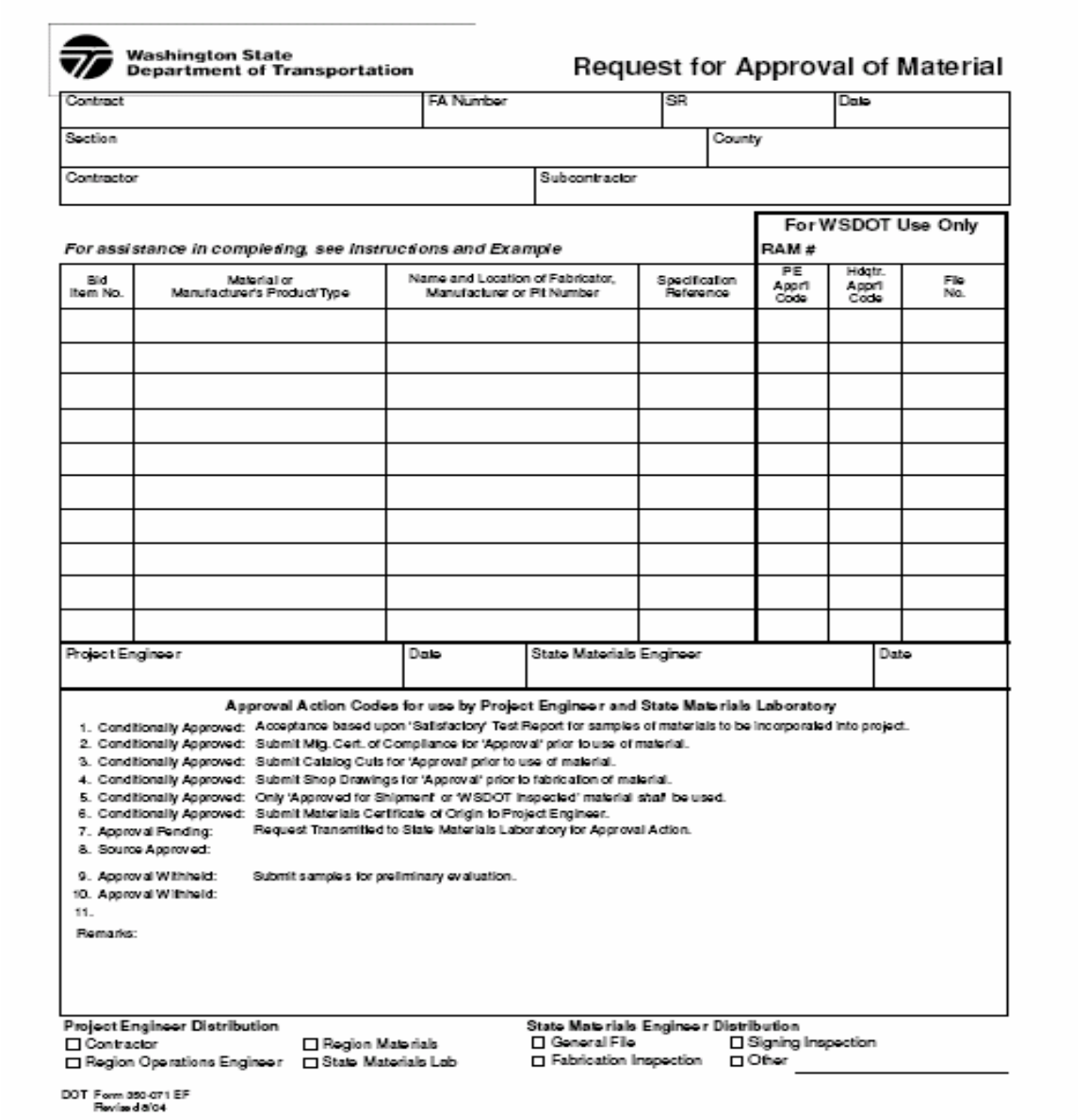
Product Description : Non-reenterable Epoxy Splice Kit
Product Restriction :

Acceptance Code : 3001
Code Description : Document the product delivered to the job site is the product that was originally submitted by the Contractor and approved from the QPL. This may be done by completing the QPL page submitted by the Contractor, filling out the 'Field Acceptance Report', the 'Field Note Record', or in the 'Inspector's Daily Report'. In all cases, record the Product name, model #, etc. Date and initial all documentation.

Last Updated: Aug 4, 2005

or be listed on a Request for Approval of Material (RAM).

The Request for Approval of Materials (RAM) is used by contractors to request materials approval for items to be used on state contracts.



Washington State Department of Transportation

Request for Approval of Material

Contract	FA Number	SR	Date

Section	County

Contractor	Subcontractor

For assistance in completing, see Instructions and Example

For WSDOT Use Only

RAM #

Bid Item No.	Material or Manufacturer's Product/Type	Name and Location of Fabricator, Manufacturer or Pit Number	Specification Reference	PE Apprl Code	Hdqtr. Apprl Code	File No.

Project Engineer	Date	State Materials Engineer	Date

Approval Action Codes for use by Project Engineer and State Materials Laboratory

1. Conditionally Approved: Acceptance based upon 'Satisfactory' Test Report for samples of materials to be incorporated into project.
2. Conditionally Approved: Submit Mfg. Cert. of Compliance for 'Approval' prior to use of material.
3. Conditionally Approved: Submit Catalog Cuts for 'Approval' prior to use of material.
4. Conditionally Approved: Submit Shop Drawings for 'Approval' prior to fabrication of material.
5. Conditionally Approved: Only 'Approved for Shipment' or 'WSDOT Inspected' material shall be used.
6. Conditionally Approved: Submit Materials Certificate of Origin to Project Engineer.
7. Approval Pending: Request Transmitted to State Materials Laboratory for Approval Action.
8. Source Approved:
9. Approval Withheld: Submit samples for preliminary evaluation.
10. Approval Withheld:
11.

Remarks:

Project Engineer Distribution

☐ Contractor ☐ Region Materials
☐ Region Operations Engineer ☐ State Materials Lab

State Materials Engineer Distribution

☐ General File ☐ Signing Inspection
☐ Fabrication Inspection ☐ Other _____

DOT Form 350-071 EF
Revised 6/04

This form is for materials not listed in the QPL. The top section of the form should be completely filled out with contract specific information, items to be approved need to be listed on the bottom section. The form is then submitted to the Project Office administering the contract. This version of the form is fax friendly and should be used in place of the older versions of the form.

Items not selected off the QPL shall be submitted to the State Materials Laboratory for appropriate action on a RAM. This list shall be complete and

cover all materials which are identified on the plans or in the specifications. The list shall include the source of supply, name of manufacturer, size and catalog number of the units, and shall be supplemented by such other data as may be required including catalog cuts, detailed scale drawings, wiring diagrams of any nonstandard or special equipment. All supplemental data shall be submitted in six copies.

The Record of Materials (ROM) from the State Materials laboratory will list items for which preliminary samples or data are required. Preliminary and acceptance samples shall be submitted as required by the ROM, received from the State Materials Laboratory at the beginning of the project or as noted on the RAM.

The Record of Materials (ROM) is a listing of major construction items provided by the Materials Laboratory, for each project. The ROM identifies the kinds and quantities of materials deemed to require quality control testing. It further identifies the minimum number of acceptance and verification samples required for acceptance of those materials. The minimum number of acceptance tests is based on the plan quantities for the project and should be adjusted for the actual quantities used. Also listed are materials requiring other actions, such as fabrication inspection, manufacturer's certificate of compliance, shop drawings or catalog cuts. The acceptance action and/or number of samples listed are the minimum requirements for the project engineer's acceptance of those materials and the minimum requirements necessary for the region's certification of the materials used on the project.

WSDOT – MATERIALS LABORATORY
Record of Materials

Existing electrical systems, traffic signal, illumination, or approved temporary replacements, shall be kept in effective operation during the progress of the work, except when shutdown is permitted to allow for alterations or final removal of the system.

Illumination system shutdowns shall not interfere with the regular lighting schedule, unless permitted by the Engineer. The Contractor shall notify the Engineer prior to performing any work on existing systems.

Work shall be so scheduled that each electrical system is operational prior to opening the corresponding section of roadway to traffic.

Traffic signals shall not be placed in operation for use by the public until all required channelization, pavement markings, illumination, signs, and sign lights are substantially complete and operational unless otherwise allowed by the Project Engineer.

All costs incurred by the Contractor for providing effective operation of existing electrical systems shall be included in the associated electrical bid items.

Excavating and Backfilling

The excavations required for the installation of conduit, foundations, poles and other appliances shall be performed in a manner to cause the least possible injury to the streets, sidewalks, and other improvements. The **trenches** shall not be excavated wider than necessary for the proper installation of the electrical appliances and foundations. Excavating shall not be performed until immediately before installation of conduit and other appliances. The material from the excavation shall be placed where the least interference to vehicular and pedestrian traffic, and to surface drainage, will occur.

All surplus excavated material shall be removed and disposed of by the Contractor in accordance with Section 2-03 or as directed by the Engineer.

The excavations for foundations shall be backfilled in conformance with applicable requirements of Section 2-09.

The Contractor shall place earth embankments in horizontal layers of uniform thickness. These layers shall run full width from the top to the bottom of the embankment. Slopes shall be **compacted** to the required density as part of embankment compaction. During grading operations, the Contractor shall **shape** the surfaces of embankments and excavations to uniform cross-sections and eliminate all ruts and low places that could hold water. The Contractor shall raise the center of an embankment above the

sides. When the surface of an embankment intersects a side hill, the surface shall be sloped away at a rate not to exceed 20:1.

Method B
The top 2 feet of each embankment shall be compacted **to 95 percent** of the maximum density as determined by the compaction control tests described in Section 2-03.3(14)D. All material below the 2-foot level shall be compacted to 90 percent of the same maximum density.

In the top 2 feet, horizontal layers shall not exceed **4 inches** in depth before compaction. No layer below the top 2 feet shall exceed **8 inches** in depth before compaction.

The Contractor shall use compacting equipment approved by the Engineer.

Under Method B, the **moisture** content of the material shall not exceed 3 percent above the optimum determined by the tests described in Section 2-03.3(14)D. If the material contains too little moisture to compact properly, the Engineer may order the Contractor to water the material in specific amounts. In this case, the Contracting Agency will pay the unit contract price for water (Section 2-07).

Backfill shall not be placed against any concrete structure until the concrete has attained 90 percent of its design strength and a minimum age of 14 days, except that reinforced concrete retaining walls 15 feet in height or less may be backfilled after the wall has attained 90 percent of its design compressive strength and curing requirements of Section 6-02.3(11) are met. Footings and columns may be backfilled as soon as forms have been removed, so long as the backfill is brought up evenly on all sides.

Excavations after backfilling shall be kept well filled and maintained in a smooth and well drained condition until permanent repairs are made.

At the end of each day's work and at all other times when construction operations are suspended, all equipment and other obstructions shall be removed from that portion of the roadway open for use by public traffic.

Excavations in the street or highway shall be performed in such a manner that not more than **one traffic lane is restricted** in either direction at any time unless otherwise approved by the Engineer.

Removing and Replacing Improvements

The outline of all areas to be removed in Portland cement concrete sidewalks, pavements and hot mix asphalt pavements shall be cut to a minimum depth of 3 inches **with a saw** prior to removing the sidewalk and pavement material. The cut for the remainder of the required depth may be made by a method satisfactory to the Engineer. Cuts shall be neat and true with no shatter outside the removal area.

Foundations

The foundations shall be located and constructed as detailed on the plans wherever possible. When foundations cannot be constructed as detailed, due to rock, bridge footings, drainage structures, or other obstructions, an effective foundation will have to be developed for the conditions encountered and approval obtained. The location of lighting standards or signal standards shall not be moved without discussing the problem with the Regional Operations/Construction Engineer and the Regional Traffic Engineer. Furthermore be aware and report any changes to the roadway, ditches, or structures that may affect the foundation elevation or alignment.

Foundations located on fills, especially those adjacent to bridge abutments, shall be deepened to provide stability as provided for in Section 8-20.3(4) of the Standard Specifications.

Foundation **concrete** shall conform to the requirements for the specified class, be cast-in-place concrete and be constructed in accordance with Section 6-02.2 and 6-02.3. Concrete for posts, standards, pedestals, and cabinets shall be constructed of concrete Class 3000, not to be substituted for commercial concrete. Steel reinforcing bars for foundations shall conform to Section 9-07.

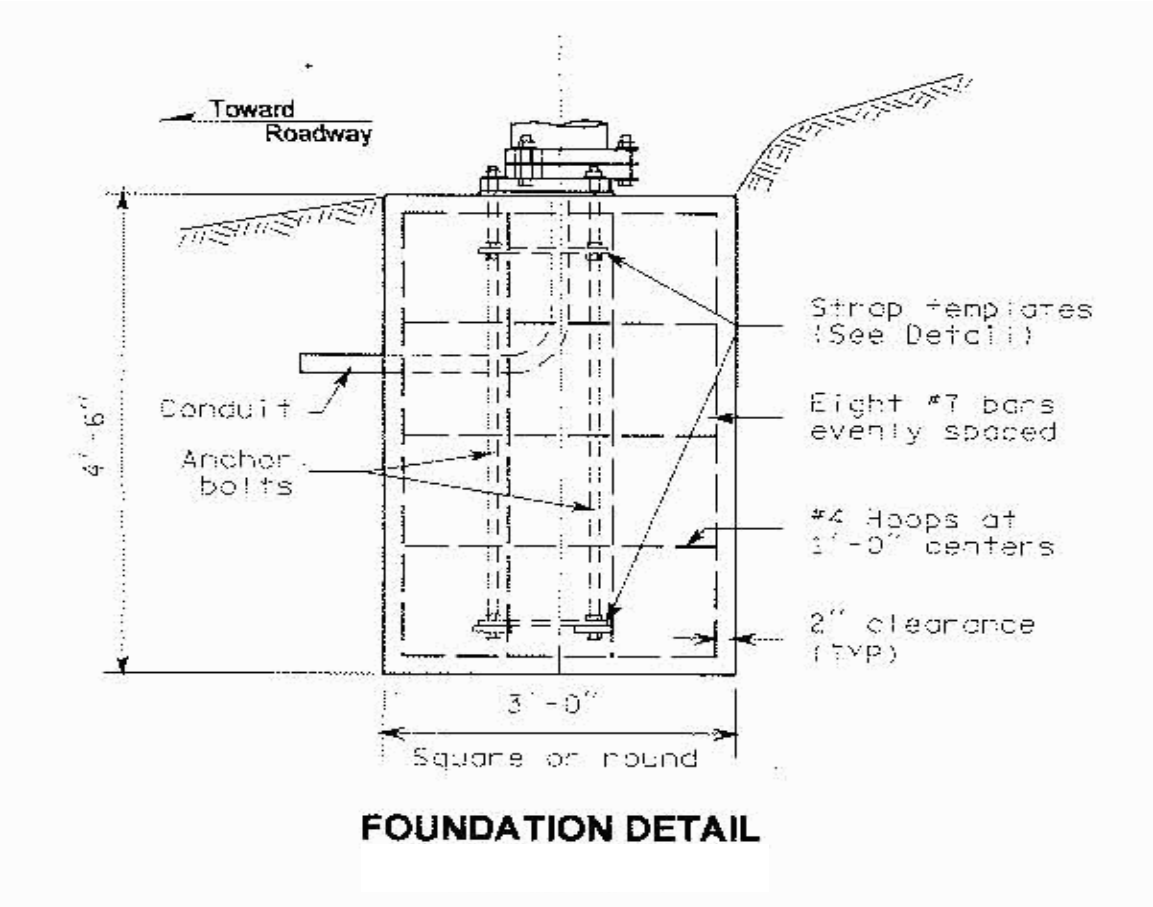
The bottom of concrete foundations shall rest on firm ground.

Foundations shall be cast in one operation where practicable. The exposed portions shall be formed to present a neat appearance.

The foundations shown in the Plans shall be extended if conditions require additional depth, and such additional work, if ordered by the Engineer, will be paid for as extra work as provided in Section 1-04.4.

Forms shall be true to line and grade. Tops of foundations for posts and standards, except special foundations, shall be finished to ground line or sidewalk grade, unless otherwise noted in the Plans or directed by the Engineer.

Forms shall be rigid and securely braced in place. Conduit ends and anchor bolts shall be plumbed and rigidly placed in the proper position and to the proper height prior to placing concrete and shall be held in place by means of a **template** until the forms are removed.



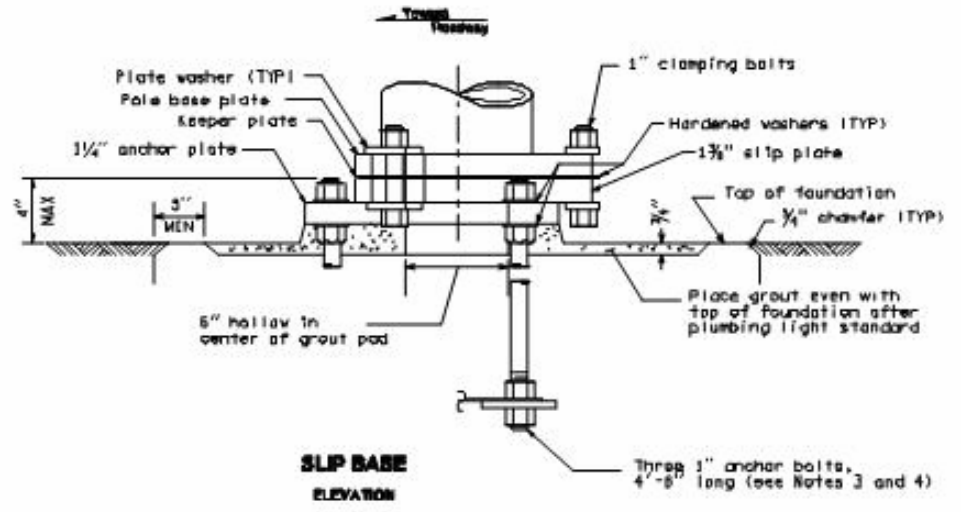
FOUNDATION DETAIL

Anchor bolts shall be installed so that **two** full threads extend above the top of the top heavy-hex nut, except that slip base anchor bolt extensions shall conform to the specified slip base clearance requirements. Anchor bolts shall be installed plumb, plus or minus 1 degree.

Both forms and ground which will be in contact with the concrete shall be thoroughly moistened before placing concrete; however, excess water in the foundation excavation will not be permitted. Foundations shall have set at least **72 hours** prior to the removal of the forms. Class 2 surface finish shall be applied to exposed surfaces of concrete in accordance with the requirements of Section 6-02.3(14)B.

Where obstructions prevent construction of planned foundations, the Contractor shall construct an effective foundation satisfactory to the Engineer.

The combined height of the light standard concrete foundation plus the anchor bolt stub height shall not exceed **4 inches** above the ground line.



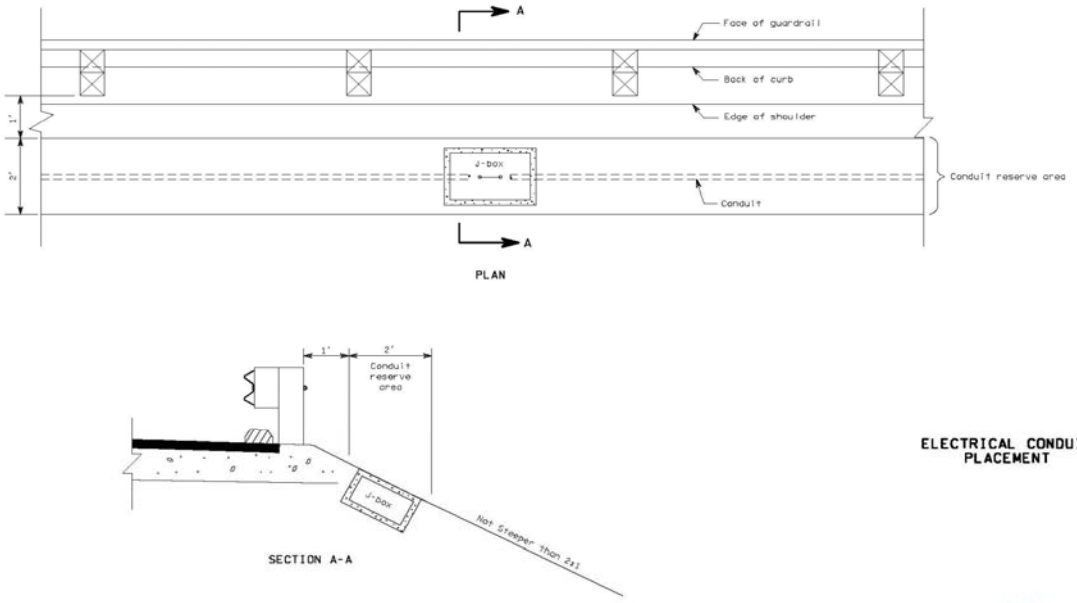
Conduit

If approval is by QPL, be certain to verify that the product is in fact qualified for its intended use, and the product is listed under the appropriate specification.

2. **Preliminary Samples**: A preliminary sample of the material will be required only if requested on Request for Approval of Material (DOT Form 350-071).

3. **Acceptance**: If using the QPL, be sure to verify appropriate means of acceptance, see applicable Acceptance Code within the QPL.

a. Galvanized conduit shall be accepted on receipt of "SATISFACTORY" test reports from State Materials Laboratory for each size and shipment. Each sample requires two 12-inch sections, one from



each end of a standard length of conduit. Re-sampling, when directed, requires twice the number of pieces specified. Be sure that matching end pieces are identified. The Project Engineer may accept galvanized conduit based on nondestructive testing according to the FOP for ASTM D 1186.

b. Fiber reinforced plastic, flexible, and plastic conduit shall be accepted on Manufacturer's Certificate of Compliance or on catalog cuts.

4. **Field Inspection**: Field verify per section 9-1.5C of the construction manual. Check for Underwriters approval labels. Check for damage to coatings in shipping and handling, and see that damaged areas and field cut threads are protected with an approved coating.

5. Specification **Requirements**: See *Standard Specifications* Section 9-29.1. Review contract documents to determine if supplemental specifications apply.

Installation of conduit shall conform to appropriate articles of the Code and the Standard Specifications.

Generally, **conduit runs** should be located on the outer shoulder areas, well away from the position where signs, delineators, guardrails and other facilities will be placed.

On new construction, all conduit located under paved surfaces shall be placed **prior** to construction of base course and pavement. It shall be the responsibility of the Project Engineer to see that all contractors on any project coordinate their work to this end.

The **size** of conduit used shall be as shown in the Plans. Conduits smaller than 1-inch electrical trade size shall not be used unless otherwise specified, except that grounding conductors at service points may be enclosed in 1/2 - inch diameter conduit.

It shall be the option of the Contractor, at no expense to the Contracting Agency, to use larger size conduit if desired, and where larger size conduit is used, it shall be for the entire length of the run from outlet to outlet. Reducing couplings will not be permitted.

The **ends** of all conduits shall be well reamed to remove burrs and rough edges. Field **cuts** shall be made square and true. Slip joints or running threads will not be permitted for coupling metallic conduit; however, running threads will be permitted in traffic signal head spiders. When a standard coupling cannot be used, an approved threaded union coupling shall be used. The **threads** on all metallic conduit shall be rust-free, clean and well painted with a good quality colloidal copper suspended in a petroleum vehicle before couplings are made up. All couplings shall be tightened so that a good electrical connection will be made throughout the entire length of the conduit run. If the conduit has been moved after assembly, it shall be given a final tightening from the ends prior to backfilling. Non metallic conduit shall be assembled using the solvent cement specified in Section 9-29.1. Where **coating** on galvanized conduit has been injured in handling or installing, such injured places shall be thoroughly painted with galvanizing repair paint, Formula A-9-73.

Formula A-9-73 — Galvanizing Repair Paint, High Zinc Dust Content

The galvanizing repair paint shall meet the requirements of Federal Specification MIL-P-21035 (Ships) Paint, High Zinc Dust Content Galvanizing Repair.

Installation of conduit should be supervised to ensure against physical abrasion of the conduit or for rust on threads which would destroy the integrity of the galvanizing.

Electrically caused corrosion of metallic conduit is easy to avoid by proper construction supervision. If the causes of this type of corrosion are not properly inspected and controlled, the extent of electrically caused corrosion is commonly far more severe than the chemically caused corrosion.

In any metallic conduit system, the metallic conduit itself serves an electrical function. This function is to provide a low resistance return path for electricity which may leak out of an electrical conductor due to scraped insulation, cracks, or other causes. A point at which electricity can leak or escape from an electrical wire is called a “fault”. When electricity flows through any non-insulated path (conduit), it can establish an electrical phenomenon called electrolysis. Electrolysis results in the transfer of metal from one location to metal at another location. Through this means, the metal that was used to make the metallic conduit may be transferred to other locations on the same conduit run or to other metallic appurtenances. With the ultimate degeneration of conduit at any point, the return path for the electricity through the conduit system itself is destroyed. In the event that a portion of a conduit was destroyed in this means and with the subsequent damage or failure of electrical conductors beyond that point, electricity would not have the ability to complete the circuit from the wire through the conduit system and return to service enclosure which would, in turn, cause a fuse to blow or a circuit breaker to trip. Hence, the protection offered by our electrical overload equipment is totally nullified.

To prevent this type of ultimate **failure** of the electrical system, all conduit joints should be carefully inspected to ensure that they are physically tight and that a good electrical bond does exist from one piece of conduit through the nipple to each adjoining piece of conduit. Additionally, conduit threads should be painted with an approved corrosion inhibiting conduit paint. Any loose or improper union between conduit sections or conduit and junction boxes is a point of high resistance to the flow of electricity. When such a condition exists and with the faulting of an electrical conductor within the system, electricity does not have an easy return to its point of service. Electricity then takes alternate routes through the earth, structures, etc. This, in particular, establishes the condition of electrolysis and results in even greater failure of the physical system. The physical system failure attributed to this may present itself from two to five years after construction.

The seriousness of this matter cannot be overstressed in electrical construction. It is so important that if one factor, and only one factor, was to be examined on each electrical project, it would be the search for conditions that would result in electrolysis and the sloppy workmanship that causes them.

Additionally, to prevent electrical **damage** to the conduit system and, in particular, during the time of project construction, the conduit shall not be used as a temporary neutral return nor shall the conduit be used for the ground of construction equipment, i.e., welders, hand tools, etc.

Conduit ends shall be **capped** (do not glue non metallic caps). Metallic conduit ends shall be threaded and capped with standard threaded conduit caps until wiring is started. When conduit caps are removed, the threaded ends shall be provided with approved conduit **bushings or end bells** (do not glue in place) for nonmetallic conduit

Conduit stubs from controller cabinet foundations shall extend to the nearest junction box in that system.

Metallic conduit stubs, caps, and exposed threads shall be painted with galvanizing repair paint Formula A-9-73.

Metallic conduit **bends**, shall have a radius consistent with the requirements of Article 344.24 and other articles of the Code. Where factory bends are not used, conduit shall be bent, using an **approved** conduit bending tool employing correctly sized dies, without crimping or flattening, using the longest radius practicable.

Nonmetallic conduit bends, where allowed, shall conform to Article 352.24 of the Code.

Conduit shall be **placed** so the top of the conduit is a minimum depth of:
1. 24 inches below the subgrade including asphalt or concrete shoulder areas and asphalt or concrete sidewalk areas.
2. 48 inches below the bottom of ties under railroad tracks unless otherwise specified by the Rail Road Company.
3. 18 inches below the finish grade in all other areas.

Galvanized steel conduit shall be installed at the following locations:
1. All roadbed crossings.
2. All railroad crossings.
3. All runs from the luminaire base to the nearest junction box.
4. All runs installed at traffic signal installations unless nonmetallic is specified in the contract provisions or plans.
5. All pole risers, except as otherwise required by owning utilities.

6. All bends with radius less than 3 feet, runs embedded within reinforced concrete structures are exempted.
7. All conduit entering junction boxes and service foundations, unless non metallic conduit is specified in the contract provisions or plans.
8. All other locations noted in the contract.
9. All runs externally attached to structures.
10. All runs installed in barrier that is constructed by slip forming.

Non metallic conduit may be employed as an alternate to metallic conduit at other locations unless specified otherwise in the contract. All conduit installation shall include equipment grounding conductors and shall conform to the requirements noted in the Standard Plans.

Liquidtight flexible metal conduit is allowed only at locations called for in the plans.
1. The use of **aluminum** conduit shall be restricted to above ground locations.
2. Aluminum conduit shall not be placed in concrete.

Metallic conduit shall be placed **under** existing pavement by approved directional boring, jacking or drilling methods, at locations approved by the Engineer. The pavement shall not be disturbed unless allowed in the Plans or with the approval of the Engineer in the event obstructions or impenetrable soils are encountered.

Boring operations shall be conducted to prevent caving ahead of the pipe, which will cause voids outside the pipe. The auger head shall precede no more than 4 inches ahead of the pipe being jacked.

The Contractor shall install **steel casings** as specified and shown in the plans.
The Contractor must be prepared to use a method approved by the Engineer to clear any obstructions to boring operations, which may be encountered.

After the casing pipe is in place, the inside shall be **cleaned** free of rock, dirt and water.

The space between the conduit and the casing shall be **plugged** with sand bags and a grout seal 12 inch thick at each end of the casing. Casings abandoned due to an encountered obstruction shall be grout sealed in the

same manner. Grout shall obtain a minimum of 4000 psi compressive strength at 7 days.

In lieu of sandbags and grout, unopened sacks of prepackaged concrete may be used to seal the casing.

Material shall not be removed from the boring pit by washing or sluicing.

Bore pits shall be backfilled and compacted in accordance with Section 2-09.3(1)E. Directional boring, and jacking or drilling pits shall be kept **2 feet** from the edge of any type of pavement wherever possible. Excessive use of water that might undermine the pavement or soften the subgrade will not be permitted.

When approved by the Engineer, small test holes may be cut in the pavement to locate obstructions. When the Contractor encounters obstructions or is unable to install conduit because of soil conditions, as determined by the Engineer, additional work to place the conduit will be paid in accordance with Section 1-04.4, **Changes.**

When **open trenching** is allowed, trench construction shall conform to the following:
1. The pavement shall be sawcut a minimum of 3 inches deep. The cuts shall be parallel to each other and extend 2 feet beyond the edge of the trench.
2. Pavement shall be removed in an approved manner.
3. Trench depth shall provide 2 feet minimum cover over conduits.
4. Trench width shall be 4 inches or the conduit diameter plus 2 inches, whichever is larger.
5. Trenches located within paved roadway areas shall be backfilled with Controlled density fill (CDF) meeting the requirements of Section 2-09.3(1)E. The controlled density fill shall be placed level to, and at the bottom of the existing pavement. The pavement shall be replaced with paving material that matches the existing pavement.

On new construction, conduit shall be placed **prior** to placement of base course pavement.

Conduit terminating in foundations shall extend a **maximum** of 2 inches above the foundation vertically including grounded end bushing or end bell.

Conduit entering through the bottom of a junction box shall be located near the end walls to leave the major portion of the box clear. At all outlets, conduit shall enter from the direction of the run, terminating **6 to 8 inches** below the junction box lid and **within 3 inches** of the box wall nearest its entry location.

Galvanized rigid steel conduit entering cable vaults shall extend 2 inches for the installation of grounded end bushing and bonding. PVC conduit entering cable vaults and pull boxes shall terminate flush with the inside walls of the structure. All conduit ends shall be terminated with termination kits.

When conduit or casing is to be placed under pavement it shall be placed **prior** to the placement of a sub base, base, surfacing, and pavement.

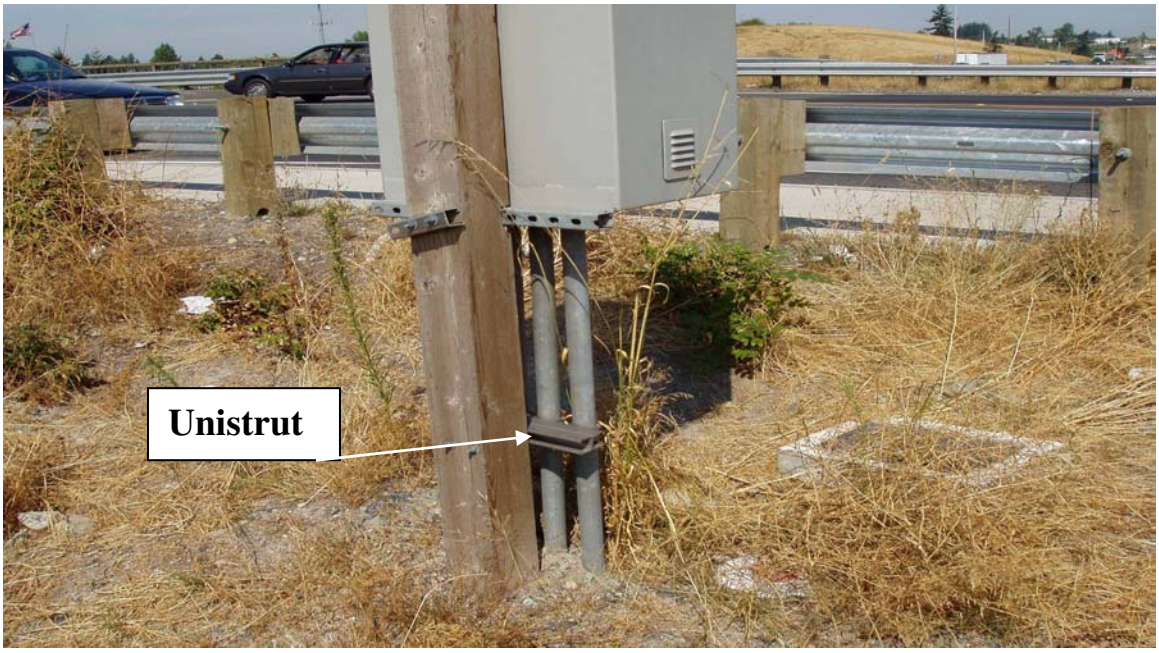
Innerduct conduit ends shall be **terminated** with termination kits. Galvanized rigid steel conduit ends shall be terminated with grounded end bushings. PVC conduit ends shall be terminated with bell ends.

Suitable **marker stakes** shall be set at the ends of conduits, which are buried so that they can be easily located.

Fittings shall be installed at locations as designated by the Engineer so as to provide a conduit channel that will permit freedom for installing the electrical control wires. When conduit fittings are called for in the Plans, or where their installation is required by the Engineer, the Contractor shall also furnish all necessary covers and gaskets.

All covered underground conduit shall be cleaned with an approved sized mandrel and blown out with compressed air prior to pulling wire.

Conduits installed for **future use** shall be prepared as follows: After final assembly in place, the conduit shall be blown clean with compressed air. Then, in the presence of the Engineer, a cleaning mandrel correctly sized for each size of conduit shall be pulled through to ensure that the conduit has not been deformed. As soon as the mandrel has been pulled through, both ends of the conduit shall be sealed with conduit caps. **All conduits scheduled for future use shall originate in a foundation or junction box as detailed in the plans and terminate in a junction box.** All equipment grounding conductors and the bonding conductor for metallic conduits shall be bonded in all junction boxes in accordance with Standard Specification 8-20.3(9).



Where surface mounting of conduit is required, supports shall consist of "**unistrut**" type or equal mounting complete with clamps sized for the conduit. Support spacing shall comply with the Code or shall be as noted in the contract. Approved expansion fittings shall be installed at all expansion joints. Approved deflection fittings shall be installed at the joint between the bridge end and the retaining wall end and the transition point from the bridge attachment to the underground section. In addition to the expansion fittings installed at all expansion joints, when PVC conduit is installed, an additional expansion fitting shall be installed for each 100 feet of conduit. Fasteners shall be as approved by the Engineer.

Existing conduit in place scheduled to receive new conductors shall have any existing conductors removed and a cleaning mandrel sized for the conduit shall be pulled through.

Conduit runs shown in the Plans are for bidding purposes only and may be changed, with approval of the Engineer, to avoid underground obstructions.

Conduit with innerduct shall be installed as shown in the Plans encased in controlled density fill. A maximum of 1000 feet of continuous open trench will be allowed, unless otherwise approved by the Engineer. All conduit with innerduct exposed above grade level, or on any elevated structures, or as noted in the plans shall be galvanized rigid steel innerduct conduit.

Innerduct warning tape shall be placed above all innerduct installed in trenches. The warning tape shall be polyethylene with a metallic backing. The polyethylene shall have a minimum of 4 mils thicknesses and be 3 inches wide. The polyethylene shall be orange in color and printed in black with the words “Fiber Optic Cable Buried Below.”

Location wire shall be placed directly above all innerduct installed in trenches.

The 4 inch outerduct shall be placed to ensure correct consistency of alignment of the innerducts.

All innerducts shall be prepared as follows:
After final assembly in place, all innerducts shall be blown clean with compressed air. Then, in the presence of the Engineer, a cleaning mandrel, correctly sized for the innerduct, shall be pulled through to ensure that the conduit has not been deformed. **As soon as the mandrel has been pulled through, a 200 lb. minimum tensile strength pull string shall be installed in each innerduct and attached to duct plugs at both ends of the innerduct.**

At all innerduct conduit **terminus points**, including those in cable vaults and pull boxes, removable and reusable mechanical plugs shall be employed as follows:
Outerduct conduits shall be plugged using a quadplex expansion plug inside the conduit around the innerduct. Duct plugs shall be installed in all unused innerducts (those that are specified as empty) at the time of conduit installation. Duct plugs shall be installed in all used innerducts (as specified in the plans) at the time of conduit installation, unless cable pulling for those innerducts will commence within 48 hours.

Innerduct containing one cable shall be plugged using an expandable split plug. Innerducts with multiple cables shall be sealed with self-expanding waterproof foam. The waterproof foam shall not be placed more than 2 inches into the innerduct.

Junction Boxes, Cable Vaults, and Pull boxes

Standard junction boxes, pull boxes and cable vaults shall be installed at the locations shown in the Plans. The Contractor may install, at no expense to the Contracting Agency, such additional boxes as may be desired to facilitate the work. Junction box installation shall conform to details in the Standard Plans.

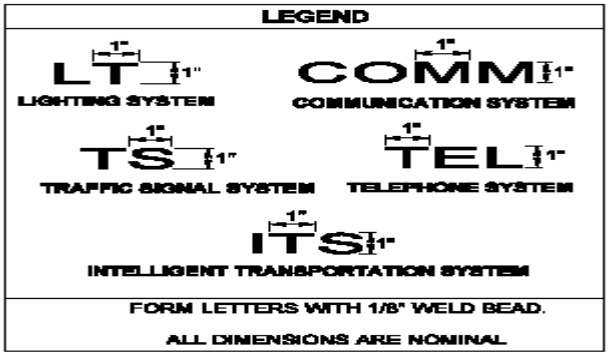
In most designs, precast concrete junction boxes are being used. These boxes are simple to install. A sump is excavated and partially filled with gravel. The open-bottom box is then seated by working it into the gravel until the required grade is reached. Care must be taken in **junction box location** to provide for drainage. Junction boxes and conduit should be placed away from areas that water is funneled to prevent it from entering into the conduits. For example, the bottom of ditches, sag vertical curves should be avoided or other low spots where water is likely to collect.

Where conduit and **junction boxes are placed in barrier**, the Prime Contractor shall coordinate the work of the Contractor constructing the barrier and the electrical Contractor so that each junction box placed in the barrier is placed in correct alignment with respect to the barrier, with the face of the box flush or uniformly chamfered within ½ inch of the barrier surface. If any point on the surface of the junction box placed in barrier is recessed more than 1/2 inch from the surface of the barrier, the Contractor

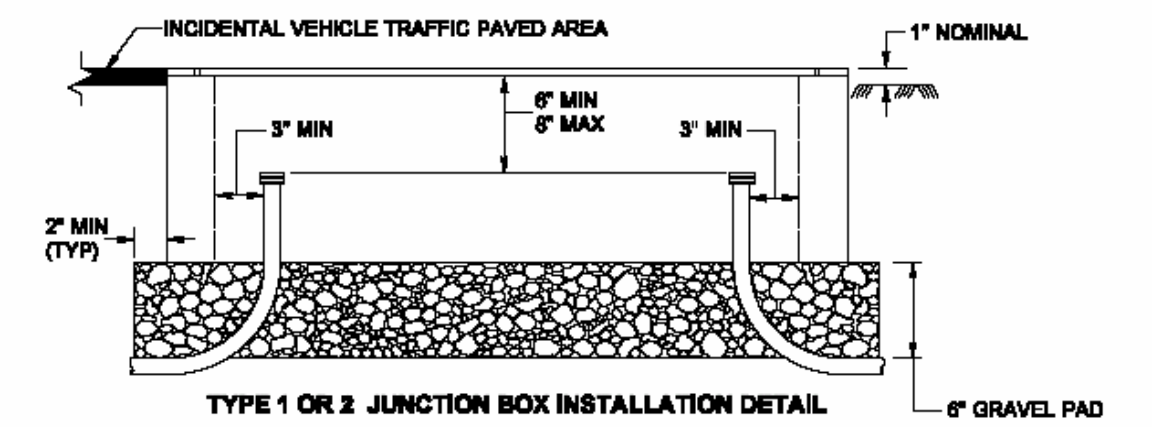
shall install a box extension meeting the Engineer's approval and grout around the extension or remove and replace the entire section of barrier.

Cable vaults and pull boxes shall be installed in accordance with the following:
1. Excavation shall be performed in accordance with Section 2-09.
2. Cable vaults and pull boxes shall be installed on 6 inches of **crushed surfacing top course**, per section 9-03.9(3), placed on a compacted or undisturbed level foundation.
3. **All openings** around conduits shall be sealed and filled with grout to prevent water and debris from entering the vaults or pull boxes. The grout shall meet the specifications of the cable vault and pull box manufacturers.
4. **Backfilling** around the work shall not be allowed until the concrete or mortar has set.
5. Pull boxes shall be installed in accordance with plans and details.
6. Pull boxes shall be configured such that the tensile and bending limitations of the fiber optic cable are not compromised. Pull boxes shall be configured to mechanically protect the fiber optic cable against installation force as well as inert forces after cable pulling operations.
7. Upon **acceptance** of work, cable vaults, and pull boxes shall be free of debris and ready for cable installation**. All grounding requirements shall be met prior to cable installation.**
8. Where installed near steel casings, the pull boxes and cable vaults shall be offset 3 feet, minimum from the centerline of the casing. Factory bends shall be used to route the conduits to the cable vault or pull box.

Junction boxes with metallic lids shall **be marked** with the appropriate legend in accordance with the bead weld details in the Standard Plans. Non-metallic lids shall be embossed with the appropriate legend and a non-skid surface. Legends for metallic lids and non-metallic lids shall be 1-inch nominal height.



Adjustments involving raising or lowering the junction boxes shall require conduit modification if the resultant clearance between the top of the conduit and the junction box lid becomes less than 6 inches or more than 8 inches in accordance with Standard Plan J-11a.



TYPE 1 OR 2 JUNCTION BOX INSTALLATION DETAIL

Cable vaults and pull boxes shall be adjusted to final grade using risers or rings manufactured by the cable vault and pull box manufacturer. Cable vaults and pull boxes with traffic bearing lids shall be raised to final grade using ring risers to raise the cover only.

All **voids** resulting from the adjustment shall be backfilled with materials matching adjacent surfacing material and compacted in accordance with Section 2-09.3(1)E.

Damage to the junction boxes, pull boxes, cable vaults and the associated conduit system, or wiring resulting from the Contractor's operations, shall be repaired to the Engineer's satisfaction at no additional cost to the Contracting Agency.

Both existing and new junction boxes, pull boxes, and cable vaults shall be **adjusted** to be flush with the finished grade as well as with the grade during the various construction stages proposed in the contract.

Messenger Cable, Fittings

Messenger cable shall be secured to steel strain poles by means of pole bands, and to timber poles by means of single strand guy eye bolts. Pole bands and eyebolts shall be installed as detailed in the Plans.

Messenger cable shall be secured to eye bolts or strain clamps at poles by the use of approved self-locking cable clamp type dead-ending devices. Messenger cable shall be secured to bull rings and anchors by two approved U-bolt connectors and guy thimbles.

Traffic signal control cable shall be secured to the messenger cable by cable ties. The ties shall be **black nylon** with ultraviolet protection and rated at 120 pound minimum unlocking strength.

Down guy assemblies shall be installed as detailed in the Standard Plans.

Wiring

If approval is by QPL, be certain to verify that the product is in fact qualified for its intended use, and the product is listed under the appropriate specification.
2. Preliminary **Samples**: A preliminary sample of the material will be required only if requested on the Request for Approval of Material (DOT Form 350-071). A sample shall consist of 15 feet.
3**. Acceptance**: Conductors shall be accepted upon receipt of "Satisfactory" Test Report from State Materials Laboratory.

a. Single Conductors: If using the QPL, be sure to verify appropriate means of acceptance, see applicable Acceptance Code within the QPL. For wire manufacturers not listed in the QPL, submit a sample. A sample shall be a length of wire that shall include the complete printed/stamped designation: manufacturer, size, and insulation type.

b. Multiple Conductors: If using the QPL, be sure to verify appropriate means of acceptance, see applicable Acceptance Code within the QPL. For wire/cable manufacturers not listed in the QPL, submit a sample. A sample shall be a length of wire that shall include the complete printed/stamped designation: manufacturer, size, and insulation type.

c. Fiber Optic Cable. A sample of the Fiber Optic cables shall be a minimum 2 feet long.

4. **Field Inspection**: Field verify per section 9-1.5C of the construction manual. A visual inspection shall be made to ensure that no conductors with damaged insulation are incorporated into the project.
5. **Specification Requirements**: See *Standard Specifications* Section 9-29.3.

For the purpose of this specification, the neutral conductor is defined as a current carrying conductor with zero potential. For the purpose of this specification, equipment grounding conductor is defined as the conductor used to connect the non current-carrying metal parts of equipment, raceways, and other enclosures to the system grounded conductor and/or the grounding electrode conductor at the service equipment or at the source of a separately derived system.

Conductors and cable shall conform as follows:
1. All current carrying **single conductors** shall be stranded copper conforming to ASTM B3 and B8. Insulation shall be 600 volt. Except as allowed in item 3, chemically cross-linked polyethylene or EPR Type USE insulation of code thickness is required for all current carrying single conductors in underground electrical systems. Grounding electrode conductor and bonding jumpers shall be bare or insulated stranded copper, AWG No. 8 minimum or larger as required by the NEC. Equipment grounding conductors shall be insulated, stranded copper with type XHHW, THWN, or USE insulation, non-jacketed AWG No. 8 minimum or larger as required by the NEC. Insulated Grounding Electrode conductors, bonding jumpers and equipment grounding conductors shall have continuous green color or green color with one or more yellow stripes.
2. **Two and three conductor** signal control cable shall consist of three, No. 14 stranded copper conductors. Each conductor shall have 20-mil polyethylene insulation and a 10-mil PVC jacket. The cable shall be rated at 600 volts minimum. The cable assembly shall be covered with a polyester tape applied with a 10 percent minimum lap. The overall jacket shall be 45-mil PVC. Four conductor through 10 conductor signal control cable shall conform to International Municipal Signal Association (IMSA) signal cable specification 20-1 except the conductor sequence color code as shown in the following table. IMSA specification cables shall use No. 14 AWG stranded copper conductors. Individual conductors shall be cabled together in accordance with the following:

Conductor Number	Color Code	Color Trace	Use
1	R	Red	Red or Don't Walk
2	O	Orange	Yellow or Spare
3	G	Green	Green or Walk
4	W	White	Neutral
5	B	Black	Ped Call or Spare
6	Wb	White/Black	Neutral or Spare
7	Bl	Blue	Ped Call or Spare
8	Rb	Red/Black	Red or Don't Walk
9	Ob	Orange/Black	Yellow or Spare
10	Gb	Green/Black	Green or Walk

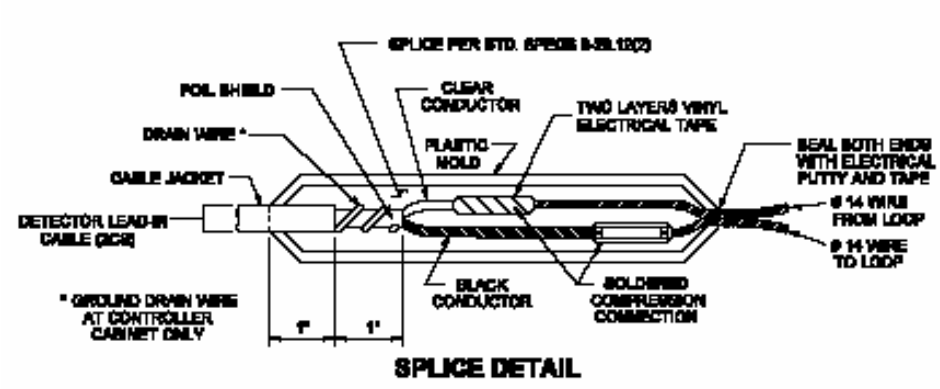
3. **All single conductors** employed in traffic control shall be Class B or Class C stranded copper. The minimum wire size shall be No. 12 AWG. Insulation shall be THW or USE, except loop wire.
4. **Triplex or Quadraplex** type ACSR neutral self-supporting aerial conductors of the appropriate size for aluminum conductors shall be used where required in the contract. The neutral conductor shall be the same size as the insulated conductor. All current carrying conductors shall be stranded.
5. **Pole and bracket cable** shall be two conductor stranded copper No. 10 AWG insulated for 600 volts between conductors. The insulation shall consist of 45-mils polyvinyl chloride with 95-mils polyethylene jacket. If luminaires with remote ballasts are specified in the contract, this same cable shall be used between luminaire and ballast for both timber and ornamental pole construction. If the luminaire requires fixture wire temperature greater than 75° C, the outer jacket shall be stripped for that portion of the cable inside the luminaire. The single conductors shall then be sheathed with braided fiberglass sleeving of the temperature rating recommended by the luminaire manufacturer.
6. With the exception of type XHHW insulation and with the further exception of the shielded two conductor cable identified in (7), and the magnetometer lead-in cable identified in (9), the **minimum insulation** thickness around any electrical conductor shall be 45 mils, and the minimum acceptable insulation thickness shall refer solely to the thickness of that insulation immediately around any conductor excluding any sheath or jacket thickness.
7**. Two conductor shielded** (2CS) cable shall have No. 18 AWG (minimum) conductors and shall conform to I.M.S.A. specification No. 50-2.

8. **Detector loop wire** may be No. 12 or 14 AWG stranded copper wire, Class B, with chemically cross linked polyethylene type USE insulation of code thickness.
9. **Four conductor shielded cable** (4CS) shall consist of a cable with four No. 18 AWG conductors with polypropylene insulation, an aluminized polyester shield, water blocking material in the cable interstices, and a 26-mil minimum outer jacket of polyethylene. The four-conductor assembly shall be twisted 6 turns per foot. Each conductor shall have a different insulation color. Overall cable diameter shall be 0.25 inch maximum. Capacitance between adjacent pairs shall be 18 pf per foot and 15 pf per foot between diagonal pairs. The capacitances shall not vary more than 10 percent after a 10-day immersion test with ends exposed in a saturated brine solution.
10**. Three-conductor shielded cable** (3CS) for the detector circuit for optical fire preemption receivers shall consist of three No. 20 AWG conductors with aluminized Mylar shield and one No. 20 drain wire, all enclosed with an outer jacket. All wires shall be 7 X 28 stranded tinned copper material. Conductor insulation shall be rated 75°C, 600 volt. The drain wire shall be un-insulated. Conductor color coding shall be yellow, blue, and orange. DC resistance of any conductor or drain wire shall not exceed 11 ohms per 1,000 feet. Capacitance from one conductor to the other two conductors and shield shall not exceed 48 pf per foot. The jacket shall be rated 800C, 600 volt, with a minimum average wall thickness of 0.045 inch. The finished outside diameter of the cable shall be 0.3 inch maximum.
11. **Six pair communications cable** (6PCC) shall meet REA specification PE-39 and shall have six pair No. 19 AWG wires with 0.008-inch FPA/MPR coated aluminum shielding. The cable shall have a petroleum compound completely filling the inside of the cable.
12. **Sign light conductors** between the junction box or other source of power and the isolation switch shall be a two conductor stranded No. 10 AWG pole and bracket cable insulated to 600 volts between conductors. The conductors between the isolation switch and the sign lighting luminaire shall be either code sized individual conductors with cross linked polyethylene type USE insulation or three conductor control cable, stranded copper No. 14 AWG cable rated at a minimum of 600 volts.

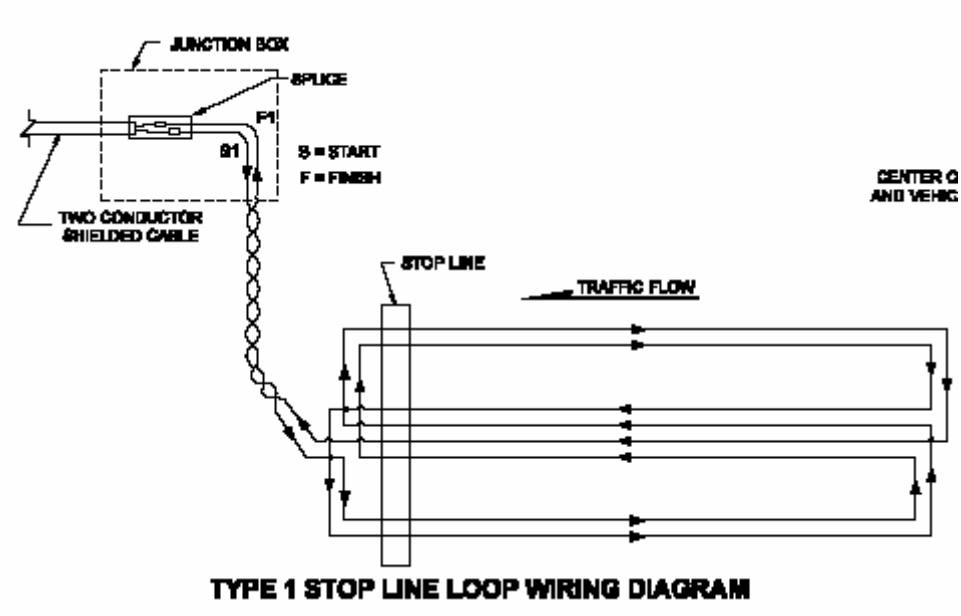
Practically all wiring for traffic signal and illumination systems is exposed to the elements, and it is very important that all splices be insulated with **waterproof material**, as prescribed in Section 8-20.3(8) and 9-29.12 of the Standard Specifications

All splices in underground illumination circuits, induction loops circuits, and magnetometer circuits shall be installed in junction boxes. The only splice allowed in induction loop circuits and magnetometer circuits shall be the splice connecting the induction loop lead in conductors or magnetometer lead in conductors to the shielded home run cable. **Splices for induction loop circuits and magnetometer circuits shall be: heat shrink type with moisture blocking, material sized for conductors, epoxy filled clear rigid mold splice kits or rigid re-enterable type splice kits**. Conductors for rigid mold kits shall be centered in the splice mold prior to installation of the encapsulation material. Magnetometer and induction loop splices shall be **soldered**. All connections with #10 and smaller wire shall use **copper crimped connectors** installed with a positive action (**ratchet**) tool, expect for quick disconnects as described in Section 9-29.7. The non insulated die shall be an indent type and insulated die shall be of a smooth shape capable of crimping pre-insulated terminals and connectors. The tool shall be compound lever type with a ratchet mechanism to ensure positive closure for full crimping cycle. The tool shall be field adjustable to proper calibration with common tools and materials. All connectors shall be **wrapped with two layers electrical tape.** All epoxy splice kits shall be physically separated from other splices and wiring within the junction box to avoid damage from heat during the casting process.

See standard plan J-8d



SPLICE DETAIL



TYPE 1 STOP LINE LOOP WIRING DIAGRAM

See standard plan J-8a

Splicing in illumination circuits will be permitted only at junction boxes. With the exception of lead-in cable to loop wire or magnetometer sensing probe splices, **no splices will be allowed in traffic signal circuitry**. All other traffic signal circuitry will be terminated at a load, at control equipment, or at a terminal.

Aerial illumination splices shall employ vice or crimp type pressure connectors. Splice insulation may be epoxy, heat shrink, or tape.

Tape splice insulation shall consist of thermoplastic electrical insulating tape applied to a thickness equal to the original wire insulation. It shall be well lapped over the original insulation, and there shall be a coating of **moisture resistant varnish applied** and allowed to dry. Two layers of friction tape will then be applied, and the splice shall be finished with a second complete coating of moisture resistant varnish.

Quick disconnect connectors, fused or un-fused as required, shall be installed at all poles supporting a luminaire. Installation shall conform to details in the Standard Plans.

Pole and bracket cable shall be installed between the disconnects and the luminaire.

Sufficient slack wire shall be installed at each junction box to allow any conductor, cable, or splice within the junction box to be raised a minimum of **18 inches outside of the box**.

Insulated grounded conductors of size No. 6 or larger shall be identified either by a continuous white or natural gray finish along its entire length or by an approved white marking for the full length of the visible conductor at all terminations, junction boxes, or accessible locations.

Every conductor at every wire termination, connector, or device shall have an approved, (9-29.13(7)B & C) **wire marking** sleeve bearing as its legend, the circuit number indicated in the contract. All terminal strips shall also bear the circuit number consistent with the contract.

At all illumination circuit splices, each wire entering the splice shall have a approved wire marking sleeve bearing as its legend the circuit number indicated in the contract.
All wiring, exclusive of the previously mentioned illumination circuits, at junction boxes and at the controller cabinet shall have an approved tag with legends as follows:
1. Individual conductors — the circuit number indicated in the contract.
2. Multiconductor cable — the numbers of the signal heads and/or pedestrian push buttons served.
3. Loop lead-in cable — the numbers of the loops served.
4. Magnetometer cable — the numbers of the magnetometers served.
5. Camera lead-in cable — the numbers of the phases the camera served.
Drip loops shall be provided on all aerial conductors where they enter poles, signal heads, or weatherheads.

Where direct burial cable or nonmetallic conduit is installed, care shall be used in excavating, installing, and backfilling, so that no rocks, wood, or other foreign material will be left in a position to cause possible injury.
Direct burial cable shall be placed a minimum of 24 inches below grade and shall be placed loosely in the bottom of a trench. An approved red warning tape shall be installed in the trench, 6 inches above the direct buried conductors.

When conductors, either cable or single, are being installed, care shall be exercised to not exceed tension limitations recommended by the manufacturer. Conductors may be pulled directly by hand. However, if conductors are pulled by any mechanical means, a dynamometer with drop-needle hand shall be used on every mechanical pull.

On mechanical pulls, insulation shall be stripped off the individual conductor and the conductor formed into a pulling eye and firmly taped, or a cable grip shall be used. The maximum pulling force applied directly to the conductor; i.e., when pulling eyes are used or when the conductor is formed into a loop, shall be limited to that shown in the following table for copper conductor. When a cable grip is applied over nonmetallic sheathed cables, the maximum pulling force shall be limited to 1,000 pounds provided this is not in excess of the force as calculated above.

Conductor	**Pounds**
8	132
6	210
4	334
3	421
2	531
1	669
1/0	845
2/0	1,065
3/0	1,342
4/0	1,693

To limit the sidewall pressure at bends in duct and conduit runs, the pulling force in pounds shall not exceed 100 times the radius of the bend in feet. **Adequate lubrication** of the proper type to reduce friction in conduit and duct pulls shall be utilized as necessary. The grease and oil-type lubricants used on lead sheathed cables shall not be used on nonmetallic sheathed cables. When wiring is noted for future connection, the ends of each wire or cable shall be sealed with an approved heat shrink end cap.

If loop lead splices are not installed immediately after the installation of the loop leads into the adjacent junction box, the ends of the two conductor "**home run**" cable shall be sealed with heat shrink end caps to prevent entry of moisture into the two conductor cable. All coaxial cables shall have heat

shrink end caps installed prior to aerial or underground installation of the cables to prevent moisture entry into the cable.

Multiconductor cable for signal displays shall be installed entirely through the mounting fitting to a point a minimum of 1 inch inside the signal display housing before the outer insulation is stripped back for the connection of individual conductors to the terminal block.

Fiber Optic Cable

Each fiber optic cable shall be suitable for placement in an underground duct.

All fibers in the cable shall be usable fibers and shall be sufficiently free of surface imperfections and inclusions to meet or exceed the optical, mechanical, and environmental requirements contained in this specification.

Cables shall be **all dielectric cable** (with no armoring) and shall be jacketed (sheathed) with medium density polyethylene. The minimum nominal jacket thickness shall be 71 mils. Jacketing material shall be applied directly over the tensile strength members. The polyethylene shall contain **carbon black** to provide ultra-violet light protection, and it shall not promote the growth of fungus.

The jacket or sheath shall be free of any holes, splits, or blisters.

The cable shall contain at least **one ripcord** under the sheath for easy sheath removal.
The shipping, storage, and operating **temperature range** of the cable shall be -40°F to +160°F. The installation temperature range of the cable shall be -20°F to +160°F.

The fiber optic cable shall withstand a **maximum pulling tension** of 600 pounds (lbs.) during installation (short term) with no damage and 135 pounds (long term).

Each optical fiber shall consist of a **doped silica core** surrounded by a concentric silica cladding.

Void areas around the individual buffer tubes shall be protected with a moisture resistant compound as a block against moisture migration.

All cables shall be free of material or manufacturing defects and dimensional non-uniformity that would:
1. Interfere with the cable installation using accepted cable installation practices.
2. Degrade the transmission performance and environmental resistance after installation.
3. Inhibit proper connection to interfacing elements.
4. Otherwise yield an inferior product.

The outer jacket material shall be a medium density polyethylene (MDPE) conforming to ASTM D 1248, Type II, Class C, Category 4 or 5, Grade J4. The light absorption coefficient, when measured in accordance with ASTM D 3349, shall be a minimum of 400 at a wavelength of 375 nanometers.

The outer jacket material used in construction of this cable shall be **fungus inert** as described in ASTM G 21.

Fibers shall contain no factory splices.

The fiber optic cables shall be shipped on **wooden reels** in lengths as specified in the purchase order with a maximum overage of 10%. The diameter of the drum shall be at least **20 times** the diameter of the cable.

Review Contract Documents to determine if supplemental requirements apply.

All **underground wiring** shall be installed in conduit unless specifically noted otherwise in the contract. All wiring in conduit shall be installed with an approved lubricant.

An electrical system is only as good as its conductors, terminals and splices, and it is important that the requirements of Section 8-20.3(8) of the Standard Specifications be strictly adhered to. If there is any doubt concerning the adequacy of a connector, the advice of the Regional Electrical Inspector should be obtained.

With the exception of induction loop circuits, magnetometer circuits and illumination circuits, **all wiring shall run continuously**, without splices, from a terminal located in a cabinet, compartment, pedestrian push button assembly, or signal head to a similarly located terminal. Illumination circuit terminals and traffic circuit signal terminals located below grade will not be allowed. Video detection systems cable installation shall follow manufacturer's specification, except no below grade terminals will be allowed.

Bonding, Grounding

Because of the hazards of electrical shock, all grounds and ground bonds referred to in the plans and in the special provisions should be given special attention to ensure their effectiveness and completeness.

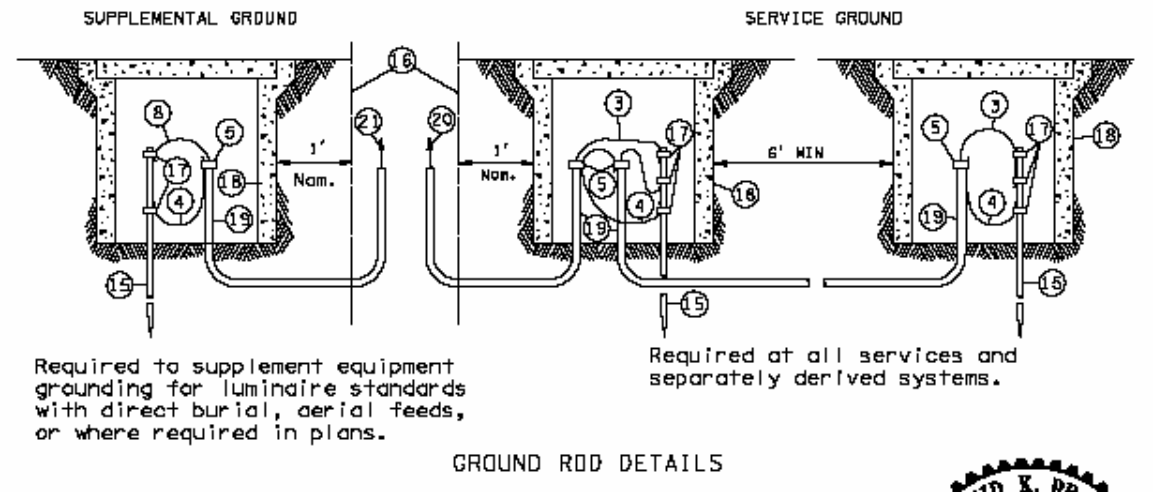
All metallic appurtenances containing electrical conductors, luminaires, light standards, cabinets, metallic conduit, non-metallic conduit, etc.) shall be made mechanically and electrically secure to form a continuous systems which shall be effectively grounded. Where metallic conduit systems are employed, the conduit system constitutes the equipment grounding conductor. Where nonmetallic conduit is installed, the installation shall include an **equipment ground conductor**, in addition to the conductors noted in the contract. Bonding jumpers and equipment grounding conductors shall be installed in accordance with Section 9-29.3. The equipment ground conductor between the isolation switch and the sign lighter fixtures may be No. 14 AWG stranded copper conductor. Where parallel circuits are enclosed in a common conduit, the equipment grounding conductor shall be sized by the rating of the largest overcurrent device serving any circuit contained within the conduit.

All connectors between bonding jumpers and equipment grounding conductors shall be installed in accordance with the NEC.

Identification of the equipment grounding conductor shall conform to all code requirements.

Grounding of the equipment grounding system and neutral at the service point shall be accomplished as required under the NEC. Grounding of the neutral shall be accomplished **only at the service**.

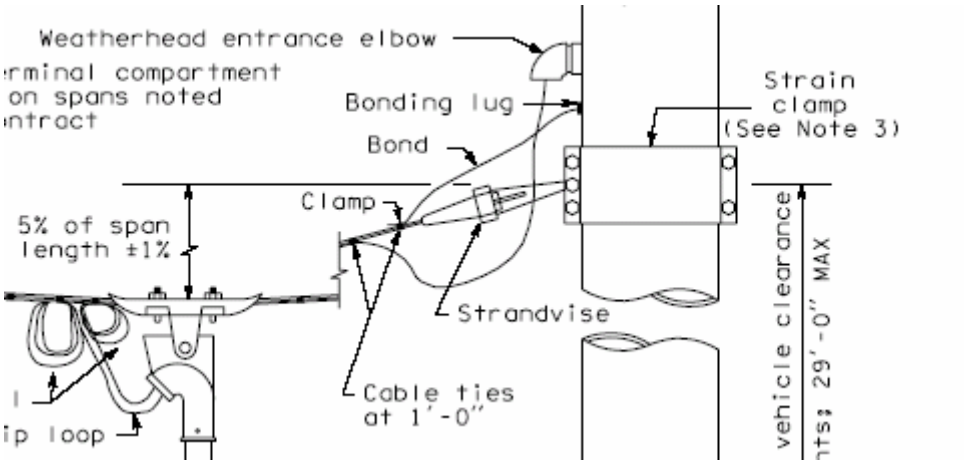
Two service grounds shall be installed at each electrical service installation and at each separately derived power source. Each service ground shall conform to the detail in the Standard Plans for "Service Ground." If soil conditions make **vertical ground rod installation** impossible see NEC Section 250-52 (c)3 as an alternate installation procedure. The service ground installations shall be located a minimum of **6 feet apart**. The first service ground rod shall be connected to a continuous grounding electrode conductor running to the service neutral bus. The second service ground rod shall be connected to the same continuous grounding electrode conductor connected to the first ground rod. Ground electrodes shall be bonded copper, ferrous core materials and shall be solid rods not less than **10 feet** in length if they are 1/2 inch in diameter or not less than **8 feet** in length if they are 5/8 inch or larger in diameter.



See standard plan J-9a!

The connection of the grounding electrode conductor to the grounding electrode shall be made with **two approved ground clamps**.

Messenger cable shall be bonded to steel strain poles by means of a bond strap connected between an approved U-bolt connector and a bonding lug on the pole.



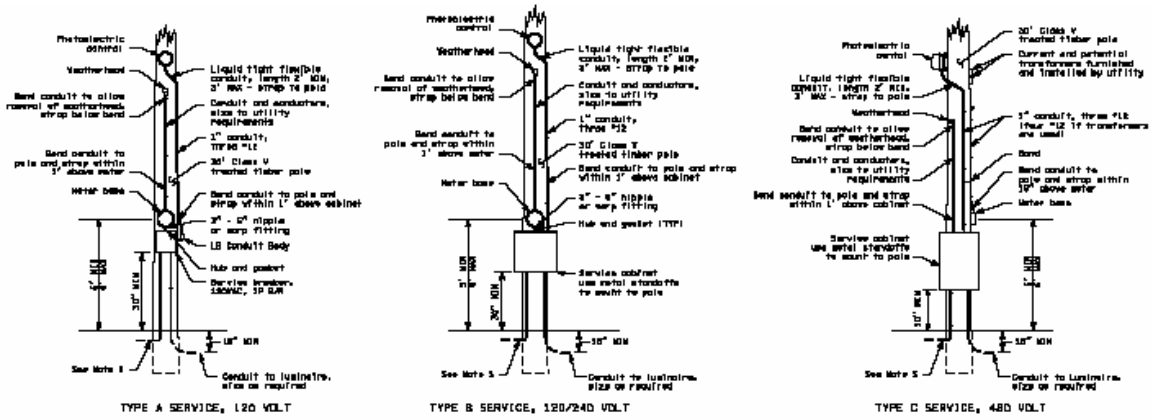
See standard plan J-7d

At points where shields or **shielded conductors** are grounded, the shields shall be neatly wired and terminated on approved grounding lugs.

Services, Transformer, Intelligent Transportation System Cabinet

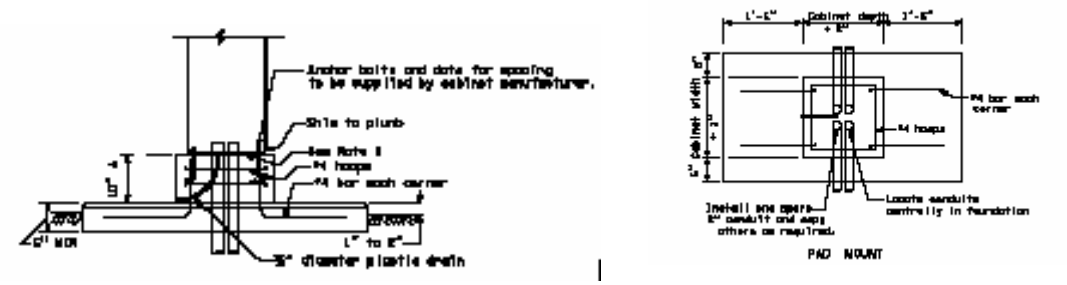
Power sources shown in the Plans are approximate only; exact location will be determined in the field.

Aerial fed **transformer cabinets** and type A, type B, or type C service cabinets shall include a **timber pole**, as specified in Section 9-29.6(3), a **meter base**, installed in accordance with serving utility requirements, a two or three wire **service breaker** of size noted in the Plans, the necessary **conduit risers** and **ground assembly** as noted in the standard plan. All timber poles used in illumination or traffic signal systems shall be Douglas fir, machine shaved, roof sawed, conforming to the latest ANSI Specifications and Dimensions for Wood Poles. All poles shall be treated with **pentachlorophenol**. Tops shall be sawed before treatment. Where holes are bored in poles to accommodate hanging bolts for brackets, transformers, guy assemblies, or other accessories, such holes shall be painted with a solution of the above preservative. The timber pole shall be set at a **depth** of 10% of the total pole length plus 2 feet.



Standard Plan J-3

Modified type B, type D and type E services shall be installed per contract plan, and service description in standard plans. **Pad mounted** transformer cabinets shall be installed per contract plans.



See standard plan J-6C

The bolt in **service breaker** shall be a standard thermal circuit breaker encased in a rain tight housing that can be padlocked.

Upon request of the Contractor, **the Engineer** will make the necessary arrangements with the serving utility to complete the service connections. **Electrical energy used** prior to completion of the contract will be charged to the Contractor, except that the cost of energy used for public benefit, when such operation is ordered by the Engineer, will be borne by the Contracting Agency.

The service, transformer and ITS **cabinets shall be marked** with the service agreement letters and numbers as noted in the plans. The markings shall be installed on the outside cabinet door near the top of the cabinet. The

markings shall be series C using stencils and black enamel alkyd gloss paint conforming to Federal Specification TT-E-489.

Commencing at the time that the serving utility makes the power drop to WSDOT electrical service cabinets, **electrical safety tags** shall be used. Any electrician working on any main or branch circuit shall cause that circuit to be de-energized and shall place an electrical safety tag at the point that the circuit is open. The electrician shall sign the electrical safety tag and only that electrician may make subsequent circuit alterations or remove the tag.

If the circuit that the electrician de-energized to work on is serving traffic, the electrician shall arrange the work so the circuit may be energized for night time operation. The electrician shall remove the safety tag and energize the circuit before leaving the jobsite and upon returning to work on the circuit, shall de-energize it again and place an electrical safety tag back on the circuit.

Testing

The Project Engineer shall insure that readings of the megohmmeter taken on every electrical circuit are furnished to the Regional Electrical Inspector. Caution must be exercised in the performance of this test to protect control mechanisms from damage due to the nature of the test voltages used. Also, the records made of this series of tests must identify the readings observed with each branch of the electrical circuit involved. Particular care shall be taken in the performance of test no. 3.

The Contractor shall conduct the following tests on all electrical circuits with nominal operating voltage between 115 volts and 600 volts, other than direct burial installations, in the presence of the Engineer:
1. Test the continuity of each circuit.
2. Test for grounds in each circuit, which shall consist of the physical examination of the installation to ensure that all required ground jumpers, devices, and appurtenances do exist and are mechanically firm.
3. A 500 volt megohm meter test on each circuit between the conductors and ground with all switch boards, panel boards, fuse holders, switches, receptacles, and overcurrent devices in place. All readings shall be recorded. The Contractor shall furnish the Engineer with three copies of the test results identifying observed readings with their respective circuits.

The **insulation resistance** shall not be less than 6 megohms between the conductor and ground on circuits with a total single conductor length of 2,500 feet and over, nor less than 8 megohms on circuits with single conductor length of less than 2,500 feet.
Any change in the above stated minimum readings must be approved in writing by the Engineer. Only those factors based on dielectric properties of conductor insulations, splicing insulations, terminal strip castings, etc., will be cause for consideration of a variance.
4. A functional test in which it is demonstrated that each and every part of the system functions as specified.

It is especially important that the Project Engineer obtain the consultation of the Regional Traffic Engineer in this portion of the field test when the tests are being performed in a traffic signal controller. Since the mechanism in these controllers is so interrelated and complex, only persons thoroughly schooled in such control mechanisms are qualified to determine when particular timing circuits and sequences are functioning properly. The simple turning on of an electrical switch and watching a light come on is not an acceptable electrical test.

For those circuits below 115 volts nominal, except induction loop circuits and direct burial circuits, the circuits shall be tested for continuity, ground, and a test to demonstrate the circuit functions as specified. The megger test shall show an insulation resistance of not less than 2 megohms to ground. Any fault in any material or in any part of the installation revealed by these tests shall be replaced or repaired by the Contractor in a manner approved by the Engineer, and the same test shall be repeated until no fault appears.

When the project includes a traffic signal system, the Contractor shall conduct tests noted in Section 8-20.3(14)D.

Test for Induction Loops and Lead-in Cable

All tests shall be performed by the Contractor in the presence of the Engineer for each loop. The tests shall be performed at the **amplifier location** after complete installation of the loop. All costs associated with testing shall be included in the unit contract prices of the respective bid items.

Test A — The DC resistance between the two lead-in cable wires will be

measured by a volt ohm meter. The resistance shall not exceed 5 ohms.

Test B — A megohm meter test at 500 volts DC shall be made between the lead-in cable shield and grounding, prior to connection to grounding. The resistance shall equal or exceed 100 megohms.

Test C — A megger test shall be made between the loop circuit and grounding. The resistance shall equal or exceed 100 megohms.

Test D — An inductance test to determine the inductance level of each inductance loop. The Contractor shall record the inductance level of each inductance loop installed on the project and shall furnish the findings to the Engineer. An inductance level below 150 microhenries is considered a failure for a Type 1 loop, any one round loop and an inductance level below 75 microhenries is considered a failure for a Type 2 loop.

The Contractor shall provide the Engineer a minimum of **five days** advance written notice of the proposed traffic signal turn-on date and time. The traffic **signal turn-on** procedure shall not begin until all required channelization, pavement markings, illumination, signs, and sign lights are substantially complete and operational unless otherwise allowed by the Engineer. The Contractor shall provide traffic control to stop all traffic from entering the intersection. The Contracting Agency electronics technician will program the controller and enter the timing data, then turn the traffic signal system to its flash mode to verify proper flash indications. The Contracting Agency electronics technician will then conduct functional tests to demonstrate that each part of the traffic signal system functions as specified. The Contractor shall conduct functional tests to demonstrate that each part of the illumination system, or other electrical system, functions as specified. These **demonstrations** shall be conducted in the presence of a Contracting Agency electronic technician, the Contracting Agency electrical inspector, and Regional Traffic Engineer or his/her designee. The Contracting Agency electronics technician will then turn the traffic signal to stop-and-go operation for no less than one full cycle **based on the results** of the turn-on, the Engineer will direct the Contracting Agency electronics technician to either turn the traffic signal on to normal stop-and-go operation, to turn the signal to flash mode for a period not to exceed five calendar days, or to turn the signal off and require the Contractor to cover all signal displays and correct all deficiencies.

If the Contractor is directed to turn off the traffic signal, the Contractor shall schedule a new turn-on date with the Engineer in accordance with the previously mentioned procedures.

A qualified representative of the controller supplier may be required to be present for the turn on to stop and go operation if the controller is being supplied on the contract.

No change to stop and go operation will be allowed after 2 p.m. on any day nor will the change be allowed on Friday, weekends, holidays, or the day preceding a holiday.

Painting

All painting required shall be done in conformance with applicable portions of Section 6-07.

Environmental Conditions

Steel surfaces shall be:

· Greater than 35ºF and

· Less than 115ºF

Or per the manufacturer's recommendations, whichever is more stringent.

Any other finish, no matter how applied, shall have a wet thickness of at least 6.0 mils per coat and a dry film thickness of at least 3.0 mils per coat.

If the specified number of coats does not produce a combined dry film thickness of at least the sum of the thicknesses required per coat, the Contractor shall apply another full coat of finish paint.

Film thickness — wet and dry — will be measured by suitable gauges. The dry film thickness will be determined by the use of a magnetic or magnetic flux dry film thickness gauge. The gauge shall be calibrated on the blasted steel with plastic shims the same thickness as the minimum dry film thickness. Wet measurements will be taken immediately after the paint is applied, and dry measurements after the coat is dry and hard.

Illumination Systems

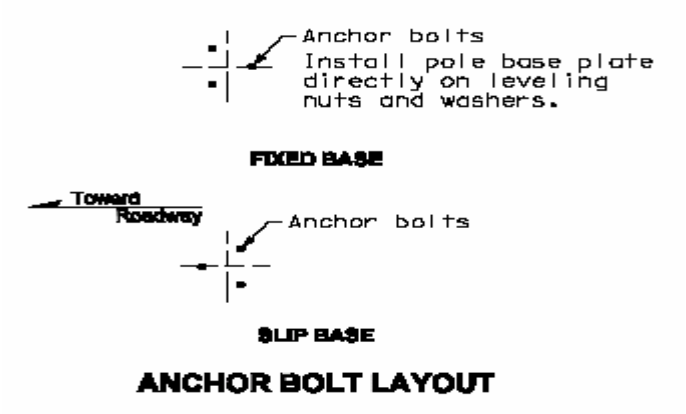
Light Standards

If **approval is by QPL**, be certain to verify that the product is in fact qualified for its intended use, and the product is listed under the appropriate specification. Notify Materials Fabrication Inspection Office of need to provide Inspection Services.
2. **Preliminary Samples**: A preliminary sample of the material will be required only if requested on Request for Approval of Material (DOT Form 350-071).
3. **Acceptance**: The fabricated poles and associated hardware will be accepted on the basis on an "Approved for Shipment" tag or stamp. If poles were inspected prior to shipment to job site, they will be stamped "APPROVED FOR SHIPMENT" An "F" or "D" will be stamped to indicate the steel or iron is of foreign or domestic origin. Certificate of Material Origin will be the responsibility of the project office. Poles not inspected prior to shipment must be inspected and approved at the job site by the Materials Fabrication Inspection Office prior to installation. Acceptance will be based on approved shop drawings and Mill Test Certificates supplied by the manufacturer. Certificates of Material Origin will be the responsibility of the project office.
4. **Field Inspection**: Field verify! Check for "APPROVED FOR SHIPMENT" stamp and the "F" or "D" indicator for foreign or domestic steel and document it. Check for damage due to shipping, handling and erection. Arrange for inspection if not tagged.
5. **Specification Requirements**: See *Standard Specifications* Section 9-29.6. Review contract documents to determine if supplemental specifications apply.

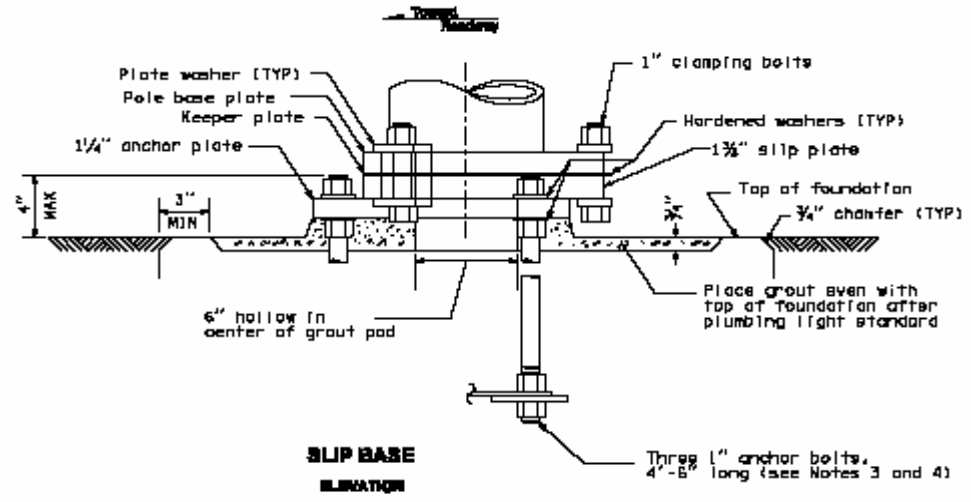
Light standards shall be handled when loading, unloading, and erecting in such a manner that they will not be damaged. Any parts that are damaged due to the Contractor's operations shall be repaired or replaced at the Contractor's expense, to the satisfaction of the Engineer.

Light standards shall not be erected on concrete foundations until foundations have set at least **72 hours or** attained a compressive strength of **2,400 psi**, and shall be raked sufficiently to be plumb after all load has been placed or as otherwise directed by the Engineer.

Slip base installation shall conform to the following:



1. The **slip plane** shall be free of obstructions such as protruding conduit or anchor bolts. The conduit, anchor bolts, and other obstructions shall terminate at a height below the elevation of the top of the slip plate.
2. **Washers** in the slip plane shall be placed between the slip plate and the keeper plate.



See standard plan J-1b sheets 1 and 2

3. **Anchor bolts** shall extend through the top heavy-hex nut two full threads to the extent possible while conforming to the specified slip base clearance requirements. Anchor bolts shall be tightened by the Turn-Of-Nut Tightening Method in accordance with Sections 6-03.3(33) and 8-20.3(4).

4. **Clamping bolts** shall be tightened in accordance with Sections 6-03.3(33)

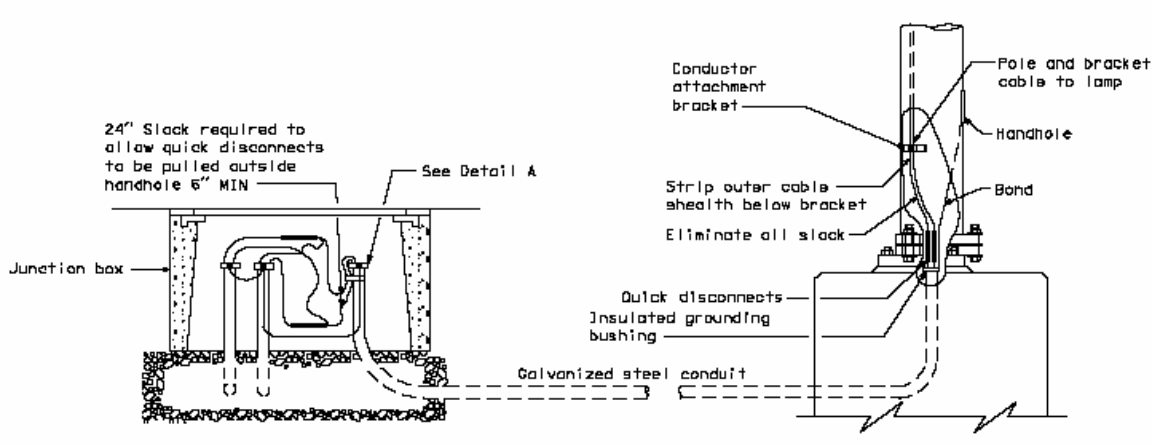
and 8-20.3(4). The clamping bolts shall be tightened to the specified torque, plus or minus 2 percent, in two stages using an accurately calibrated torque wrench before erecting the light standard. Except as otherwise specified, the Contractor shall install 1 inch diameter clamping bolts in all slip bases to a torque of 95 foot-pounds. The Contractor shall tighten the 1 1/8 inch diameter clamping bolts of slip bases for 50 foot light standards with double 10 foot mast arms or greater to a torque to 104 foot-pounds. Burr threads!

5. The **galvanized surfaces** of the slip plates, the keeper plate and the luminaire base plate shall be smooth, without irregularities, to reduce friction and to prevent slackening of bolt tension due to flattening of the irregularities.

6. **Anchor bolts damaged** after the foundation concrete is placed shall not be repaired by bending or welding. The Contractor's repair procedure is to be submitted to the Engineer for approval prior to making any repairs. The procedure is to include removing the damaged portion of the anchor bolt, cutting threads on the undamaged portion to remain, the installation of an approved threaded sleeve nut and stud, and repairing the foundation with epoxy concrete. Epoxy concrete shall meet the requirements of Section 9-26.3(1)B.

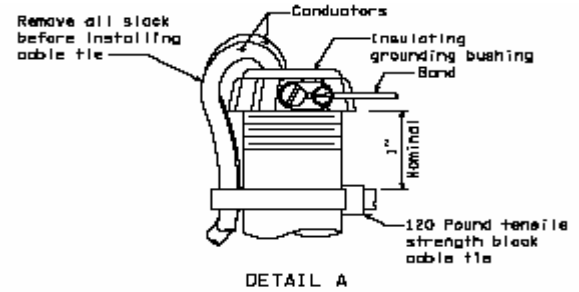
7. The **grout pad** shall not extend above the elevation of the bottom of the anchor plate.

8. **Wiring** for slip base installation shall conform to details in the Standard Plans.



WIRING DETAIL LIGHT STANDARD SLIP BASE*

*Application for fixed base similar except no cable tie is required at junction box.



See standard plan J-1e

Breakaway coupling installation shall conform to the following:
1. At existing foundations, the anchor nuts, pole, grout pad, and leveling nuts shall be removed. Conduits shall be cut to a maximum height of 2 inches above the foundation including grounding end bushing or bell end. Galvanizing repair paint, conforming to Formula A-9-73 in Section 9-08.2, shall be applied to the cut conduit that has been threaded. Anchor bolts that are damaged shall be repaired with approved sleeve nuts as noted under slip base installation procedures.
2. Anchor bolts shall be cut off 2-1/2 to 3 inches above the foundation. At new foundations, the anchor bolts shall be installed with top of bolt 2-1/2 to 3 inches above the foundation.
3. Couplings shall be installed to within 1 /8 to 3 /8 inch of the foundation. Couplings shall then be leveled.
4. The pole shall be set and plumbed; and washers, nuts, and skirt installed per manufacturer's recommendations.

Slip base insert installations shall conform to details in the Standard Plans, and shall conform to items 1 through 8 above for slip base installation, except that the **specified torque** for the 7/8 inch diameter clamping bolts shall be 50 foot-pounds. Burr threads!

All new light standards shall have an approved **metal tag** riveted to the pole above the hand hole. The information provided on the tag shall be as noted on the pre-approved drawings. The following information shall be stamped on the tag:

1. Luminaire number.
2. Luminaire wattage.
3. Luminaire voltage.

All new or relocated metal light standards shall be **numbered** for identification in accordance with the Plans using painted 3-inch series C numbers installed 3 feet above the base facing the traveled way. **Paint** shall be black enamel alkyd gloss conforming to Federal Specification TT-E-489.

Where existing illumination or traffic signal systems are to be removed, and the material stockpiled at the site of the work for delivery to WSDOT, it will be advantageous if **prior arrangements** are made to have Department personnel meet the contractor at the delivery storage site. These arrangements should be made with either the Regional Maintenance Engineer or the Regional Traffic Engineer.

Decorative Light Standards

Design and fabrication shall meet or exceed the requirements of the latest AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals.

Complete calculations for the structural design, including anchor bolt details, shall be prepared by a professional engineer licensed under Title 18 RCW State of Washington, in the branch of Civil or Structural Engineering. All **shop drawings and cover page** of all calculations submittals shall carry signature, original seal, registration number and date of expiration. The cover page shall include the contract number, contract title and sequential index to calculation page numbers. Two copies of the associated design calculation shall be submitted for approval along with shop drawings.

Luminaires

The Contractor shall **mark the installation date** on the inside of the luminaire ballast housing using a permanent marking pen.

All luminaires shall be mounted level, both transverse and longitudinally, as measured across points specified by the manufacturer. Leveling and orientation shall be accomplished after pole plumbing.

If approval is by QPL, be certain to **verify** that the product is in fact qualified for its intended use, and the product is listed under the appropriate specification.

High pressure **sodium** cobra head luminaires shall be capable of accepting a 150, 200, 250, 310, or 400 watt lamp complete with ballast. Metal halide fixtures shall be capable of accepting a 175, 250 or 400 watt lamp complete with ballast. **Mercury** vapor fixtures shall be capable of accepting a 175, 250, 400 watt lamp complete with ballast. Metal **halide** fixtures shall accept a 175 watt mercury vapor lamp complete with ballast. **Each** luminaire shall consist of a housing, reflector, lens, lamp socket, an integral ballast, and a terminal strip and lamp.

All luminaires shall be of the IES distribution type and wattage indicated in the contract. Luminaires shall be installed with HPS lamps rated at 24,000 hours, unless otherwise specified in the contract.

The **temperature rating** of all wiring internal to the luminaire housing, excluding the pole and bracket cable, shall equal or exceed 200° F.

All luminaires shall be provided with **markers** for positive identification of light source type and wattage. Markers shall be 3 inches square with Gothic bold, black 2 inch legend on colored background. Background color shall be **gold for sodium**, **blue for mercury**, and **red for metal halide** light sources. Legends shall be sealed with transparent film resistant to dust, weather, and ultraviolet exposure.

Legends shall correspond to the following code:

Lamp	**Wattage Legend**
70	7
100	10
150	15
175	17
200	20
250	25
310	31
400	40
700	70
750	75
1,000	XI

2. **Preliminary Samples**: Preliminary samples will be required only if requested on Request for Approval of Material (DOT Form 350-071). Submit Manufacturers Certificate of Compliance and catalog cut to the State Materials Laboratory for evaluation if requested.
3. **Acceptance:** Verify the materials received on the job site, is in fact the same make, model, lot, batch, size, color, blend, etc. as approved for use, be it by QPL or via the Request for Approval of Material (DOT Form 350-071).
4. **Field Inspection**: Field verify per section 9-1.5C of the construction manual.

a. **Luminaires**: A visual inspection shall be made to ensure damaged equipment is not installed and that luminaires are mounted level. Confirm the socket position is the same as that noted on the catalog cut.

b. **Lamps** for Luminaires and Signal Heads: **Check** that all lamps are of the proper wattage, see contract documents.
5. **Specification Requirements**: See *Standard Specifications* Section 9-29.10. Review contract documents to determine if supplemental specifications apply.

Cobra Head Luminaires

Conventional highway luminaires shall be IES Type III cut off type distribution cobra head configuration with horizontal lamp. The ballast shall be mounted on a separate door, which shall be hinged to the luminaire and secured, in the closed position to the luminaire housing by means of an automatic type of latch (a combination hex/ slot stainless steel screw fastener may supplement the automatic type latch). The reflector of all luminaires shall be of a snap-in design or be secured with screws. The reflector shall be manufactured of polished aluminum or molded from prismatically formed borosilicate glass. The refractor or lens shall be mounted in a doorframe assembly which shall be hinged to the luminaire and secured in the closed position to the luminaire by means of automatic latch. The refractor or lens and doorframe assembly, when closed, shall exert pressure against a gasket seat. The refractor lens shall not allow any light output above 90 degrees nadir. Gaskets shall be composed of material capable of withstanding temperatures involved and shall be securely held in place.

Each housing shall be provided with a slip fitter capable of mounting on a 2 inch pipe tenon. Vertical mounted luminaires shall be appropriately sized for

their respective pole top tenon and capable of being adjusted within 5° from the axis of the tenon. The clamping bracket(s) and the cap screws of the slip fitter shall not bottom out on the housing bosses when adjusted within the ±5° range.

No part of the slip fitter mounting brackets on the luminaires shall develop a permanent set in excess of 0.2 inch when the cap screws used for mounting are tightened to a torque of 32 foot pounds.

Decorative Luminaires

Decorative fixture shall provide for a 150 - 400 watt HPS lamp fully enclosed fixture with mogul lamp socket, adjustable where required to alternate cutoff distributions.

The fixture shall be a one piece, box shaped, rain tight, dust tight and corrosion resistant, integral unit. The unit shall consist of an accessible ballast compartment and a sealed housing which permits filtered pressure equalization.

The ballast housing shall be fabricated of close tolerance extruded aluminum with heat resistant vinyl finish. The housing shall be adequately constructed to contain ballasts for 150 - 400 watt alternate high intensity discharge sources.

Each housing shall consist of an integral Alzak reflector, containing a mogul based high intensity discharge lamp, a rigid box type lamp holder assembly, a reflector assembly with a lamp vibration damper, and a one piece heat and shock resistant, clear tempered lens mounted in a gasketed, hinged, and baffled extruded aluminum frame. The housing shall have vinyl heat resistant finish. One fourth inch stainless steel, series 300 fasteners shall secure the lens frame to the housing.

The auxiliary equipment compartment for ballast terminals shall be separated from the lamp compartment by a metal heat barrier. The chassis shall be designed to provide effective heat sinking from the ballast cores. Capacitors shall be mounted at least 5 inches from the core and coil components.

Fixtures shall be finished alternately with paint or epoxy primer and either acrylic enamel; vinyl clad aluminum or powdered polyester baked on paint. Aluminum compatible epoxy primer shall be applied. The finish coat shall be dark bronze in color matching Federal Standard 595B or as shown in the contract.

Without chipping or flaking, the finish shall withstand 5 foot pounds direct or indirect impact from a falling cylindrical steel rod 7/8 inch diameter, a hemispheric nose and shall be salt spray resistant after 300 hours exposure in accordance with ASTM B 117 shall not cause blistering, peeling, corrosion or loss of adhesion.

Decorative fixtures shall be mounted using a reinforced mounting arm, milled to provide a smooth fit between fixture and arm. A slip fitter assembly shall be provided for leveling purposes, between fixture and tenon. Two 7/16 inch or larger stainless steel bolts, series 300, shall be used to mount the fixture to the tenon. An approved gasket shall be utilized to seal against weather. A smooth wire way shall be provided.

All decorative fixtures shall be of the same manufacturer and external appearance.

High Mast Luminaires and Post Top Luminaires

High mast and post top luminaires shall comply with the requirements of the contract and Section 9-29.9 except the unit lamp shall utilize a vertically positioned lamp. High mast luminaries shall be 400 watt HPS full 90^{o} nadir cut off, capable of types 2, 3, 5 distribution or as shown in the contract. When installed at heights between 50 and 70 feet the bottom of the fixture shall be closed, at heights from 70 to 85 feet the bottom shall be open. High Mast luminaire poles with mounting heights greater than 50 feet shall have approved fixture **lowering devices** installed and two **remote control** units, to operate the lowering device.

Post top luminaires shall have the ballast located directly below the vertical installed HPS lamp. All post top luminaires shall be capable of accepting 70, 100, 200, 250, 400 watt HPS lamps complete with ballast assembly.

Under-deck and Wall Mount Luminaires

Underdeck luminaires shall be weatherproof and corrosion resistant. Light distribution shall be as shown on the contract. Each flush-mounted underdeck luminaire shall consist of a metal body, a prismatic refractor mounted in a doorframe, a prismatic glass or specular anodized aluminum reflector, a ballast, and a ceramic lamp socket and be supplied complete with all fasteners. The body shall have provisions for anchoring to concrete. The refractor shall be glass and shall be clearly identified as to "street side." The doorframe assembly shall be hinged, gasketed and secured to the body.

Each wall-mounted luminaire shall consist of a metal body, a prismatic refractor mounted in a doorframe, an aluminum reflector with a specular anodized finish, an integral ballast and a ceramic lamp socket and supplied with all fasteners. The refractor shall be glass. A gasket shall be provided between the refractor and the body of the fixture.

All lamp sockets shall be positioned to locate the light center of the lamp within ½ inch of the light center location for which the luminaire is designed.

Ballasts for underdeck and wall luminaires shall conform to the provisions in Section 9-29.9. Ballasts for underdeck and wall mount luminaires shall be installed in the luminaire housing

Signal Systems

Signal Controllers

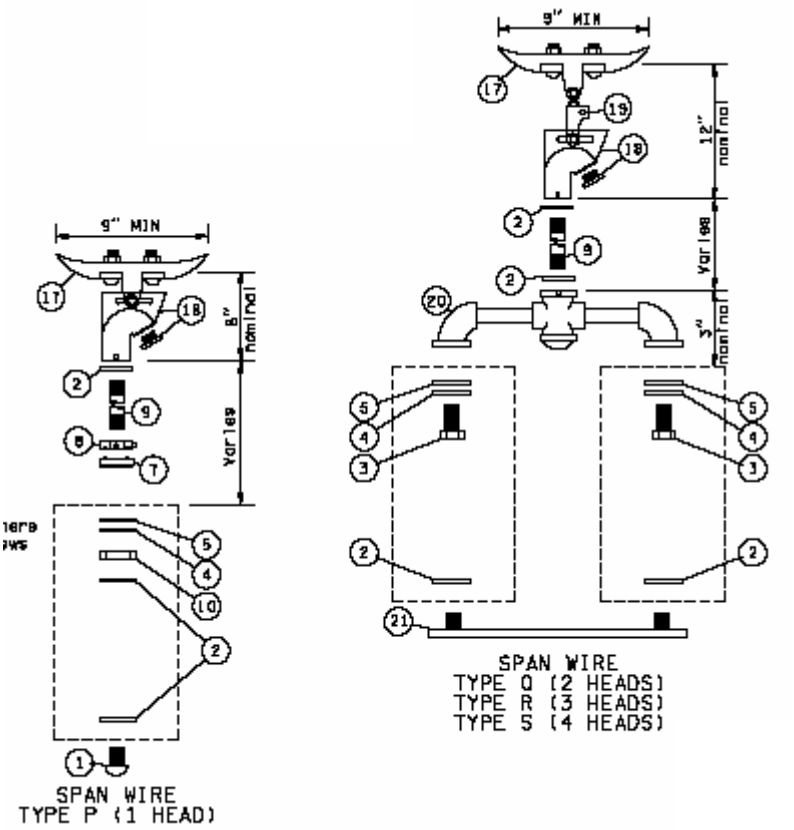
All control cabinets and control equipment shall be **factory wired** ready for operation. Field work will be limited to placing cabinets and equipment and connecting the field wiring to field terminal strips. All controller cabinets shall be installed on a **silicone seal pad**.

Controllers for portable traffic signal systems shall conform to the requirements of Section 9-29.13(7).

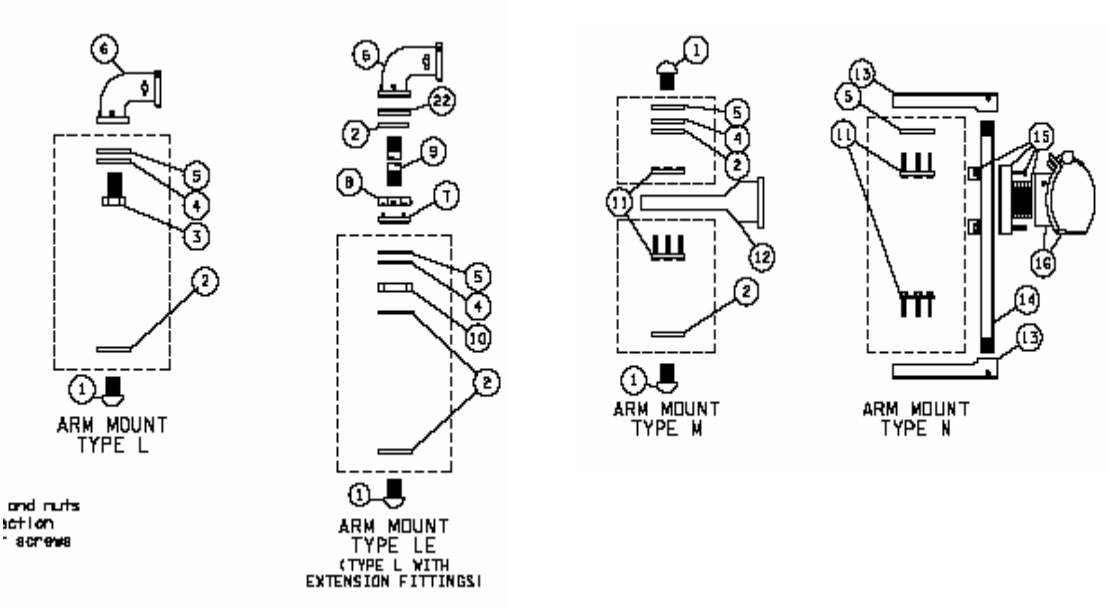
Signal Heads

Unless ordered otherwise by the Engineer, signal heads shall **not be installed** at any intersection until all other signal equipment is installed and the controller is in place, inspected, and ready for operation at that intersection, **except** that the signal heads may be mounted if the faces are covered to clearly indicate the signal is not in operation.

Three section displays mounted on type M mounts shall have the plumbizer between the top and second display. Four and five section vertical displays mounted on type M mounts shall have the plumbizer between the second and third display.



Ensure correct installation of signal heads!



See standard plan J-6g

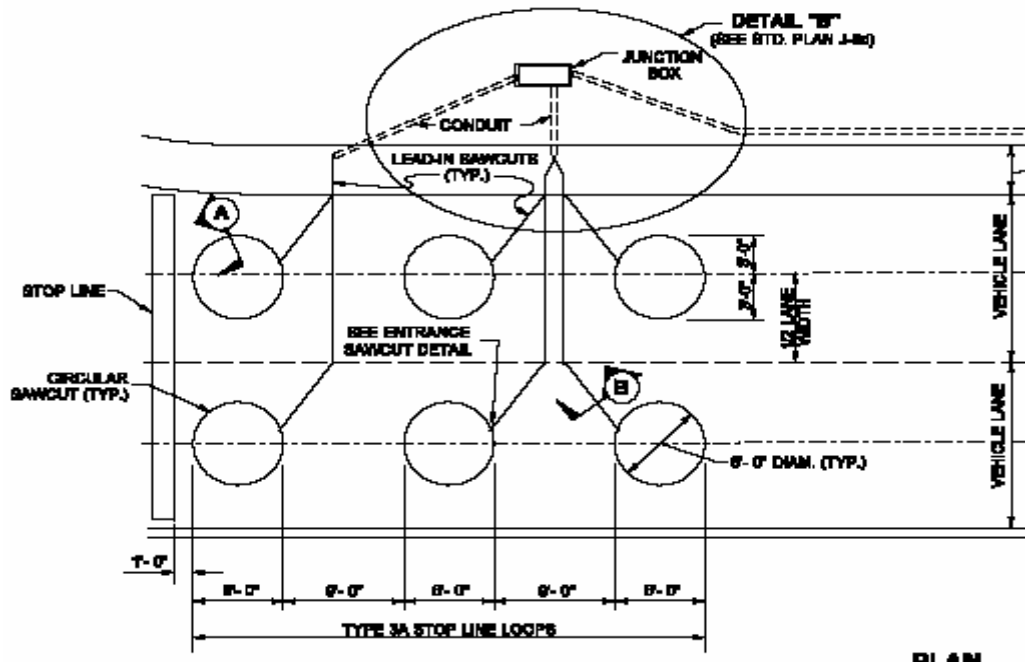
Induction Loop Vehicle Detectors

Induction loops shall be constructed as detailed in the Contract and the following:

1. Loop wire shall conform to Section 9-29.3.

    8. Detector loop wire may be No. 12 or 14 AWG stranded copper wire, Class B, with chemically cross linked polyethylene type USE insulation of code thickness.

2. When Type 2 or 6' round (R) loops are grouped at the stop line, the front



See standard plan J-8c

edge of the first loop shall be one foot behind the stop line. Each additional loop installed in the lane shall be on 15 foot centers.

3. Lead-in cable shall conform to Section 9-29.3.

    7. Two conductor shielded (2CS) cable shall have No. 18 AWG (minimum) conductors and shall conform to I.M.S.A. specification No. 50-2.

4. All loops shall be installed **after grinding** or prior to paving the final lift of asphalt designated in the Contract. **Loop conductors** shall be held at the bottom of the saw cut by high temperature **backer rod** (sized to fit snugly in the saw cut). **Two inch** long pieces of the backer rod shall be installed on **24 inch centers** along the entire loop and home run(s) and at the entrance and exit of all turns greater than 45°. If new loops are installed over existing, the

old loops **shall be removed** by grinding and the grinding shall be deep enough to destroy any existing operational loop conductors. If not listed as incidental to another item or paid for under another bid item the additional work to remove the existing loops shall be paid in accordance with Section 1-04.4.
5. **Each loop** shall be the size and number of turns indicated in the Plans.
6. No loop installation will be done in rainy weather or when the pavement is wet.
7. All **saw cuts** shall be cleaned with a high pressure washer and dried with 100 psi minimum air pressure, to the satisfaction of the Engineer. If traffic is allowed over the saw cut prior to wire installation, the saw cuts shall be cleaned again.
8. **Wiring** shall be installed with a blunt-nosed wooden wedge.
9. Prior to the installation of the Hi temperature backer rod all **slack** shall be removed from the wiring. Kinks in wiring or folding back of excess wiring will not be allowed.
10. **High temperature backer rod**, sized for snug fit shall be installed in the saw cut on 2' centers and at all sharp turns.
11. Install **sealant** as per contract or as approved by the Engineer.
12. Sealant shall be applied such that air bubbles or foam will not be trapped in the saw cut.

Test for Induction Loops and Lead-in Cable

All tests shall be performed by the Contractor in the presence of the Engineer for each loop. The tests shall be performed at the amplifier location after complete installation of the loop. All costs associated with testing shall be included in the unit contract prices of the respective bid items.

Test A — The DC resistance between the two lead-in cable wires will be measured by a volt ohm meter. The resistance shall not exceed 5 ohms.

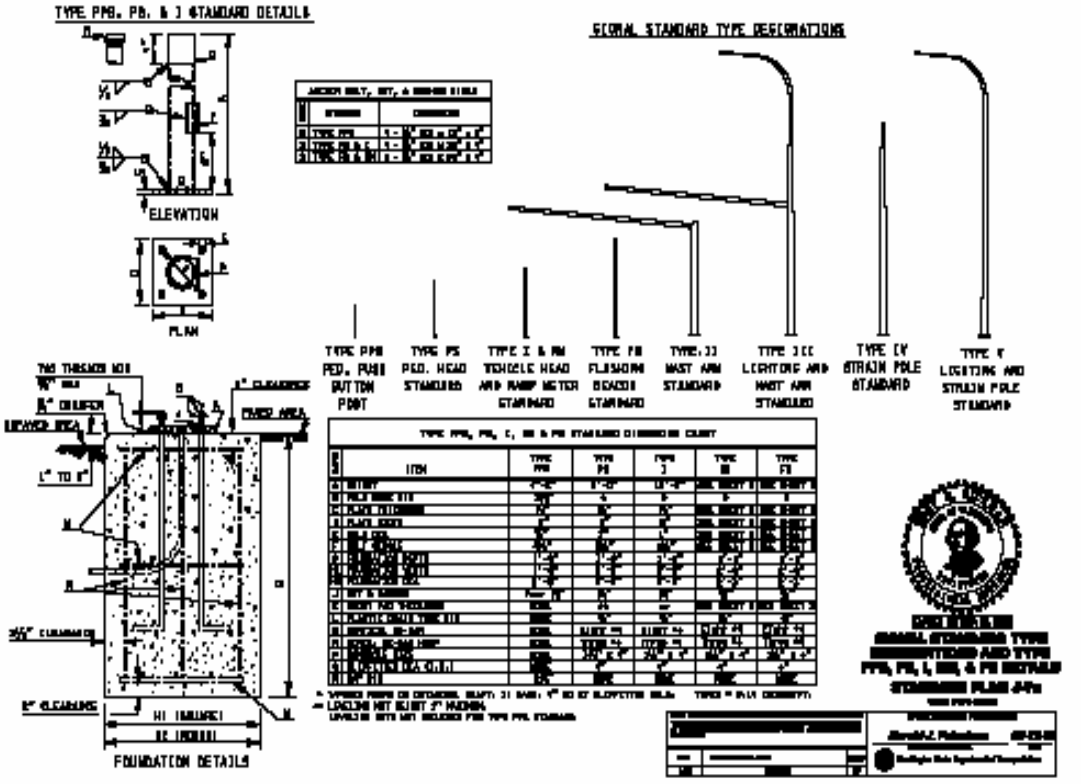
Test B — A megohm meter test at 500 volts DC shall be made between the lead-in cable shield and grounding, prior to connection to grounding. The resistance shall equal or exceed 100 megohms.

Test C — A megger test shall be made between the loop circuit and grounding. The resistance shall equal or exceed 100 megohms.

Test D — An inductance test to determine the inductance level of each inductance loop. The Contractor shall record the inductance level of each inductance loop installed on the project and shall furnish the findings to the Engineer. An inductance level below 150 microhenries is considered a failure for a Type 1 loop, any one round loop and an inductance level below 75 microhenries is considered a failure for a Type 2 loop.

If any of the installations fails to pass all tests, the loop installation or lead-in cable shall be repaired and replaced and then retested.

Signal Standards



See standard plan J-7a and your contract plans

If approval is by QPL, be certain to verify that the product is in fact qualified for its intended use, and the product is listed under the appropriate specification. Notify Materials Fabrication Inspection Office of need to provide Inspection Services.

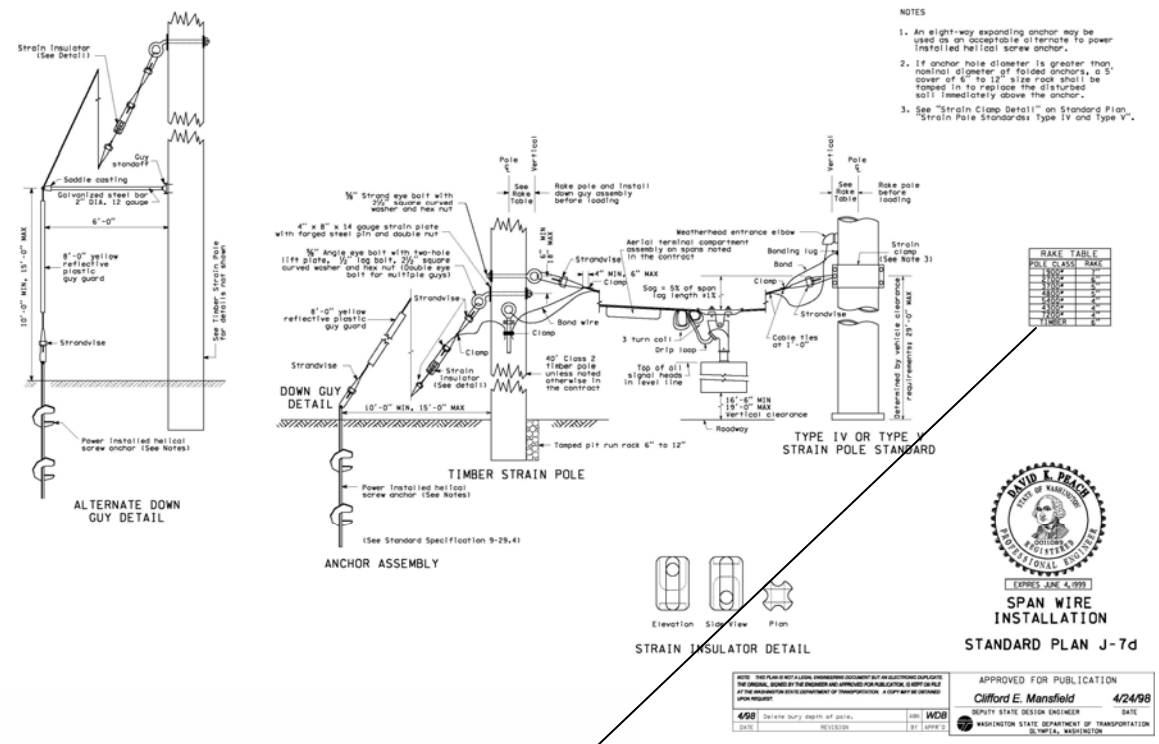
2. Preliminary **Samples**: A preliminary sample of the material will be required only if requested on Request for Approval of Material (DOT Form 350-071).
3. **Acceptance**: The fabricated poles and associated hardware will be accepted on the basis on an "Approved for Shipment" tag or stamp. If poles were inspected prior to shipment to job site, they will be stamped "APPROVED FOR SHIPMENT" An "F" or "D" will be stamped to indicate the steel or iron is of foreign or domestic origin. Certificate of Material Origin will be the responsibility of the project office. Poles not inspected prior to shipment must be inspected and approved at the job site by the Materials Fabrication Inspection Office prior to installation. Acceptance will be based on approved shop drawings and Mill Test Certificates supplied by the manufacturer. Certificates of Material Origin will be the responsibility of the project office.
4. **Field Inspection**: Field verify! Check for "APPROVED FOR SHIPMENT" stamp and the "F" or "D" indicator for foreign or domestic steel and document it. Check for damage due to shipping, handling and erection. Arrange for inspection if not tagged.
5. **Specification Requirements**: See *Standard Specifications* Section 9-29.6. Review contract documents to determine if supplemental specifications apply.

Traffic signal standards shall be furnished and installed in accordance with the methods and materials noted in the contract and the following:
1. All dimensions and orientations will be field verified by the Engineer prior to fabrication.
2. The signal standard component identification shall conform to details in the Plans.
3. Disconnect connectors complete with pole and bracket cable shall be installed in any signal standard supporting a luminaire. Illumination wiring installation shall conform to details in the Plans for slip base wiring.
4. No field drilling will be allowed on signal mast arms except for the installation of any required pre-empt indicators , pre-empt detectors, microwave detector, or type "N" signal mountings. The maximum diameter shall be 1 inch.
5. All pole entrances required for pole-mounted signal heads, cabinets, signs, pedestrian push button assemblies, etc., shall be field drilled.
6. Damage to the galvanized pole surface resulting from field drilling shall be repaired with approved zinc rich paint.

7. Field welding will not be allowed, except as shown in the Plans or as otherwise approved by the Engineer.
8. All tenons shall be factory installed.
9. All welding shall be completed prior to galvanizing.
10. Foundations shall be constructed to provide the pole orientation noted in the Plans. Anchor bolts shall be tightened in accordance with Sections 6-03.3(33) and 8-20.3(4).
11. Slip base installation for Type RM and FB signal standards shall conform to the slip base installation requirements specified in Section 8-20.3(13)A, except that the specified torque for the 3/4 inch diameter clamping bolts shall be 50 foot-pounds.
12. The pole shall be plumbed after signal heads are installed.
13. The space between the bottom base plate and the top of foundation shall be filled with grout with **a 3/8 -inch plastic drain tube**.

Signal standards shall not be erected on concrete foundations until the foundations have attained 60 percent of its design strength or 14 days. Signal standards without mast arms may be erected after 72 hours. Type IV and V strain pole standards may be erected but the messenger cable (span wire) can not be placed until the foundation has attained 60 percent of its design strength or 14 days. Signal supports used with portable traffic signal systems shall provide a minimum of two signal displays, spaced a minimum of 8 feet apart.

When portable traffic signals are used to provide alternating one way control, a minimum of one of the signal displays shall be suspended over the traveled way. The **minimum vertical clearance** to the traveled way for this signal display is 16 feet 6 inches.



RAKE TABLE	
POLE CLASS	RAKE
1900#	7"
2700#	6"
3700#	5"
4800#	5"
5400#	4"
4300#	4"
~~7200#~~	~~4"~~
TIMBER	6"

To "Rake" is to lean the pole back to compensate for the weight of the mast arm or attached cables!

Grout for Anchor Bolts

Grout shall be a **prepackaged grout**, mixed, placed, and cured as recommended by the manufacturer, **or** the grout shall be produced using

Type I or II Portland cement, fine aggregate Class 1 or Class 2, and water, in accordance with these Specifications.

Grout shall meet the following requirements:

Requirement	Compressive Strength
Test Method	AASHTO Test Method T 106
Values	4,000 psi @ 7 days

Grout shall be a workable mix with flowability suitable for the intended application.

If the Contractor elects to use a prepackaged grout, a material **sample** and laboratory test data from an independent testing laboratory shall be submitted to the Engineer for approval with the request for approval of material sources.

If the Contractor elects to use a grout consisting of Type I or II Portland cement, fine aggregate Class 1, admixture, and water, the mix proportions and laboratory test data from **an independent test laboratory** shall be submitted to the Engineer for approval with the request for approval of material sources.

The Contractor shall receive approval from the Engineer before using the grout.

Field grout cubes shall be made in accordance with WSDOT Test Method 813 for either prepackaged grout or a contractor provided mix when requested by the Engineer, but not less than one per bridge pier or one per day.

Before placing grout, the concrete on which it is to be placed shall be thoroughly cleaned, roughened, and wetted with water to ensure proper bonding. The grout pad shall be cured as recommended by the manufacturer or kept continuously wet with water for three days.

After all grout under the masonry plate and in the anchor bolt cavities has attained a minimum strength of 4,000 psi, the anchor bolt nuts shall be tightened to snug-tight. “Snug-tight” means either the tightness reached by (1) a few blows from an impact wrench, or (2) the full effort of a person

using a spud wrench. Once the nut is snugtight, the anchor bolt threads shall be burred just enough to prevent loosening of the nut.

Reinstalling Salvaged Material

When salvaged electrical equipment is to be reinstalled, the Contractor shall furnish and install all necessary materials and equipment, including anchor bolts, nuts, washers, concrete, etc., required to complement the salvaged equipment in the new installation.

Metal poles relocated to new permanent locations shall be inspected for structural integrity prior to reinstalling.

"As Built" Plans

Upon physical completion of the work, **the Contractor** shall submit corrected shop drawings, schematic circuit diagrams, or other drawings necessary for the Engineer to prepare corrected plans to show the work as constructed.

These drawings shall be on sheets conforming in size to the provisions of Section 1-05.3 of the Standard Specifications.

The Project Engineer is required to submit As-Built Plans in accordance with Chapter 10-3.7 of the Construction Manual. For proper maintenance and repair of the electrical system, it is imperative that the location of all conduits and the diagram of all circuits be properly shown on the As-Built Plans.

Normally, the conduits should be constructed in the locations shown on the contract plans. Many times these conduits are positioned in a particular place to eliminate conflict with future construction.